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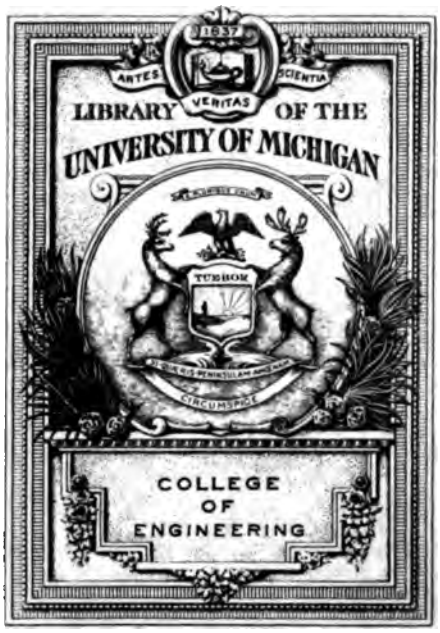

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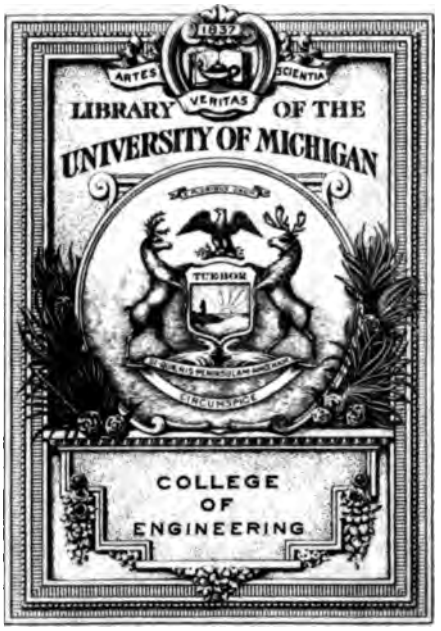

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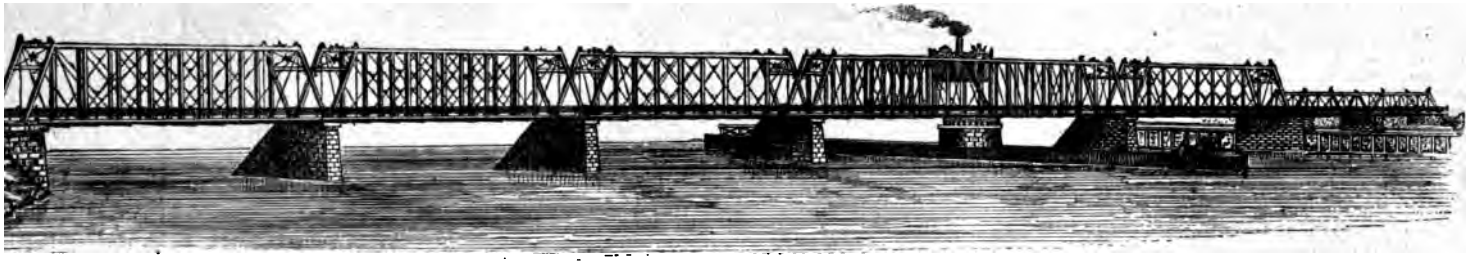

THE MICHIGAN

ENGINEERS' ANNUAL,

CONTAINING THE

PROCEEDINGS OF THE MICHIGAN ENGINEERING SOCIETY,

FOR 1889.

The Eleventh Annual Convention will be held in January, 1890, on call of the Board of Directors.

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1889.

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MICHIGAN ENGINEERING SOCIETY.

Papers and Discussions at the Tenth Annual Convention, held at Lansing, Jan. 22-24, 1889.

PRESIDENT'S ADDRESS.

Members of the Michigan Engineering Society: —

It was with much hesitancy that I assumed the office which by a majority of your ballots, was made imperative. And now to think of giving any direction to your thoughts or plans, seems like presumption itself. I am certainly very grateful for the honor conferred, and like a boy with his pocket full of goodies belonging to another, will promise "not to do so any more." At this our Tenth Annual Convention, held at the Capitol, where our first organization was effected, a retrospective view shows the wisdom of organization. The proceedings of other similar societies, nearly all formed since this one, evince a growing impulse toward improvement. So much is this true that a copy of society proceedings is received as a long-desired letter from a friend, and studied through and through, to learn what others are doing. These exchanges will in time make a useful addition to our libraries, and I recommend that they be carefully filed and bound. It is the active worker and searcher after facts, in these days, who stands foremost; and our Society, as such, and each individual member, should be no exception to the law. The duty is thrust upon us, and two words express the situation — *Do* or *die*.

It will not do to say we have done very well so far, and are satisfied with our attainments. "The mill will never grind with the water that is past." There is room enough up higher for the energetic surveyor and engineer, and he can always be improving from observation, study, and the teaching or experience of others.

And how better can we make advancement than by the association with others which this Society gives, and by making others' needs our own? We are not here to hear sweet words and dulcet melodies. The daily duties in office and field may well be sus-

pended; and while we profess to meet as business men, on business errands, a strict discussion of the program is our repast, and all the panacea we expect or need. Our doors are always open, and if a stranger or an honorable legislator walks this way, we shall not say him "nay." The only admission is, to such, a modest notice or recognition of our body, among other societies which grace the pages of the "Red Book." Perhaps, then, through a little official courtesy, and by keeping company with the Bee-keepers and Stock-breeders, we can make a decent appearance among some of our own Michigan people; and they may learn that nine years ago some of the lonely and disconsolate surveyors met around the dais of the pioneer room of the Capitol, and organized what has now grown to be the incorporated "Michigan Engineering Society;" that it takes hold of the live questions of surveying and civil and mechanical engineering, and we believe the more aid and encouragement it receives, the better for the State at large. Surely the grave questions of boundary lines and corners, the proper platting of villages, the location of drains and highways, the construction of bridges, the improvement of railways and rolling stock, the warming and sewerage of dwellings, the best management of steam for various purposes, and many other such topics, are directly connected with our substantial growth and progress as a State. What other profession does more? What other can better wield the destiny of any people? Its failures are far-reaching, and Panama follies are turned into a Pandora's box of all evil. Our own State is large, diversified, and calls for the best surveyors, engineers, and mechanics. Its progress even in the last twelvemonth, in railroad building, the platting of new villages, and the starting of manufactories calling for all kinds of machinery, is surprising. It would be the more so were it not that Michigan men have become accustomed to Michigan speed. We can realize how fast the driving-wheels go, by *dropping out of the car!* Are these statements too extravagant? Not intentionally. The facts bear us out. Nov. 6, 1888, Michigan cast 475,356 votes for presidential electors, which, at the usual estimate of population, would give 2,200,897, an increase in the last four years of 344,797. We said our State calls for the *best* surveyors and engineers, and we mean that each shall find his proper place in due time. The skimmed milk is in one jar, the cream in another. When the people learn by experience that work half done is dear at half price, and that good surveyors and engineers do not, on call, jump out of a ballot box, there will be greater advancement. The influence of this Society should be such as to say to every struggling one, "We will help you," and it should just as unmistakably discourage tramps, whether they travel along the highways with their earthly effects stowed in two old boots, or meander along the farm lines with compass and chain. What the State is doing at the Normal School, University, and Agricultural College to give a thorough

and complete course in practical, civil, mechanical, and mining engineering, and what it has lately commenced in the Mining School at Houghton, should be kept in vigorous progress. No parsimony should now cripple the good work being done. We are on the right track. The *hand* and the *brain* are *both being educated*, and by and by the young men who have gone out from these schools will have some of the shop dust to wipe off from their diplomas on to those of the kid-gloved kind who never make stir enough to raise a dust.

If the State can graduate from any of these institutions a class who would degrade intelligent labor, then just so far has it been unfaithful, and has squandered the public money. That the contrary is generally true, we believe, and the many responsible places filled by these graduates will abundantly prove.

We have reason for gratitude to the Giver of all good that our membership has suffered no loss by death since our last meeting at Kalamazoo, and for that general prosperity which prevails, and which has brought into greater requisition the engineers' services. We have had no disturbing strikes of laborers to stop engineering work, and be it said to our praise that there has been none of the trades-union spirit in which our members use the Society to make unusual and selfish demands; but all seem to be actuated by that spirit which shall better their knowledge in their respective branches of work and professional study, and thus make their united effort a public as well as a private good.

Our Secretary is to be specially commended for the neat and attractive annual report, and the several circulars and notices sent. This is a matter which requires good judgment and care to put it in the right hands for execution, and one which adds much to our proceedings. The present program brought out by the Executive Committee, in part, at their annual meeting in October last, and by the Secretary, after much correspondence, shows a most home-like and practical Michigan face. These topics are live ones, and are from those who are prepared to speak from experience. We hope it may afford sufficient variety. It has been said in our hearing that the engineers are now running this Society, and there is not a place for surveyors. If one would stop to think how dull is the music of the best hand-organ when played without intermission, and how impossible to sustain such an organization as this without due regard for each individual member, perhaps such a remark would not obtain. To my own knowledge, there has not been a session of this Society which did not afford ample opportunity to introduce any questions germane to our objects as set forth in the second subdivision of the Articles of Association.

It was thought best in the organization not to provide any standing committees, as used to be our custom, and still is with similar societies, the reason being that a committee of several members was not easy to convene, and no one member wanted to take the

work alone, when there were others who should assist. I would therefore recommend that some topics be assigned to special committees, of one member each, who will be expected to do thorough work in the line assigned him, and report at our next annual Convention.

1. It would be well to have a special committee on *Questions of Practice*, with principal reference to surveyors' work, and any member during the year may address such committee freely with any question he needs light upon, and the decision of the committee shall be rendered subject to review by the Society. It is expected, however, that if the committee is not well prepared, an answer may be made after correspondence with other members. We well recollect the day when, isolated in the Northern Michigan woods, away from any surveyor whom we could consult, and lacking guide-books, such a correspondence with an able committee of such a State organization would have been very pleasant, to say the least.

2. A special committee on *Decisions*. This committee would be able to give us at our next Convention, a resumé of any important decision of State or United States courts bearing on boundary, or any matter of interest to this Society. One member making a speciality of this will be likely to bring together the most in that department.

3. A special committee on *Photography* as applied to Engineering. Of this subject we expect more will be said before the close of this session, but as it is now prominently before us, and is somewhat of a new feature, it would be well to prepare for next year's Convention early. The committee would be expected to interest any amateur photographer to make an exhibit, or by a little effort could himself make a loan of views for use a few days. The portraits of any eminent engineers would be a very pleasant feature for reference and study, while our next Convention was held. Many useful details would suggest themselves to the committee.

There may be still other subjects which could be best prepared by a special committee of one, and if any member will call them up, we will be pleased to have him.

The advertising pages of the Annual Report are well filled, and it suggests the thought that these dealers and those who make an effort to exhibit instruments at our Conventions, are especially worthy of patronage by the members of our Society.

The annual Convention, with its social greetings, is too infrequent. So, too, are the opportunities of our members to consult together, and improve themselves by this means. It would be more than we may reasonably expect to do to meet semi-annually, as the expense to some is now considerable, and more than it would be if all our attending members purchased certificates for reduced fare. Our Society presented the anomalous condition at the last Convention of having so many who were connected with

railroads, and thereby entitled to passes, that the others were compelled to pay full fare both ways. It would seem that on account of the good work this Society is doing for the railroads, and other engineering matters, some way might be devised so that every member could be assured of getting reductions to one and one-third fare. As it is, it reduces our attendance, and discourages those who come.

In connection with the idea of more frequent meetings is this; the failure of our State Institutions to benefit the people as they might, not *per se*, but because the people at large do not demand a different course. How little is known throughout the State what is being done and what is the *daily thought* at these institutions! The students know, and so do the Professors in charge. But both probably have too much to do already. We see results when a class is graduated. Then a sweltering crowd listen to music, and the sweet patter of words set to the latest rhetorical rhythm, and they go away to come again the next year, and so on. The graduates file out from this modern Parthenon, and Michigan people have the pleasure of reading a long list of names in the catalogues. Is it not wrong to give so many advantages to the few, at the expense of the many, when both might be subserved? We have seen that the population of Michigan is over 2,200,000. Now instead of limiting our State institutions to the service of the few who are able to attend them directly, a large number of our thoughtful, studious, and isolated people should be kept constantly informed of the current thought of these schools. Is there not some way in which these superheated bodies can send a little daily or weekly warmth to the distant regions of Michigan? or cannot the people be in closer contact with them by means of the press? Take the Surveying and Engineering Departments: How much is being worked out that would be useful to every one of this class? Both successes and failures should be spread abroad. You say that this is done by occasional reports and bulletins. And we answer, they *are too occasional*. Give these schools each a good active reporter, and the means to pay him, or turn some of the usual appropriations to a different purpose, and let us know by minute reports to the daily or weekly papers *just what they are talking about*. The people are the students, and they are sitting with their feet hanging from the rough back-woods benches, listening for something from these schools. Let these enlarge their borders, so that the whole State shall be their campus! The engineers are interested in this general question with its special application to their needs, and perhaps can use their influence with the "powers that be" to bring about these desirable conditions. If so, our meeting shall not be in vain.

With a most earnest desire for the good of every member, and our best wishes for a pleasurable session, I bid you, *Speed the Program*.

GEO. E. STEELE, *Pres.*

MUNICIPAL ENGINEERING.

To the President and Members of the Michigan Engineering Society: —

GENTLEMEN: Believing it to be the duty of each member of this Society to perform his quota of the necessary work, and responding to the request of the Secretary, I present herewith a paper on "Municipal Engineering."

Municipal engineering includes the construction, care, and maintenance of streets, sewers, water-works, bridges, etc., and, in a word, is intimately connected with all kinds of municipal public works.

The subject being of such general scope, it was found necessary, in order to keep this paper within proper confines, to generalize, rather than enter much into details.

In the contemplated improvement of a city by the grading or paving of its streets, the first step to be taken is the preparation and adoption of general plans, in order that, as these improvements are made from year to year, the several parts shall work harmoniously into the whole.

Before proceeding with the preparation of general plans, bench marks should be established throughout the city, with reference to some assumed datum line; levels should then be taken, extending over the entire limits of the city, and from these levels a topographical map be made in order that the engineer may intelligently prepare a grade map, or plan, for street improvements, or a plan for a general sewerage system; and all street improvements of a permanent nature should, thereafter, be made in conformity with the general plan.

In the case of sewers, after deciding upon the system to be adopted, whether a separate or combined system, by the aid of the topographical map the proper location of the main and lateral sewers can be decided upon, and no deviations should be made from said plan, except for very good reasons.

A question which will invariably confront the authorities of young cities which are about to make public improvements, is, "How shall the work be paid for?" Various cities have various methods. Some pay for the improvements by issuing tax receipts to the contractor, who is then supposed to collect the taxes for the improvement; others issue orders to the contractor, drawn upon a special fund created by assessment upon the property benefited, the orders, in some cases, drawing interest. Others, again, pay for the work in cash during the progress of, or upon the completion of, the work, the city realizing money for this purpose by the sale of its bonds running a certain number of years, and drawing a fixed rate of interest. This last method is the most economical for the city and its citizens, as it insures the contractor against loss

by failure on the part of some property owners to pay promptly their proportion of the cost of the improvement. The contractor will therefore not be required to put the amount of money into the work that he would were he compelled to wait for the collection of taxes before realizing anything from the job; and hence he will do the work cheaper. Not only this, but it gives a wider field for competition. It permits the contractor of limited capital to compete with the man who has a bank behind him. It gives better satisfaction to the persons who execute the work and to the persons who pay for it; to the persons who execute the work, because upon its completion and acceptance, they are paid all that is due them; and their interest therein ceases; to the persons who pay for the improvement, because they realize that they are paying far less than they would were the contractor paid in orders or tax receipts, thus compelling him to place his figures high enough to provide against loss and delay.

Where work is paid for otherwise than in cash, the party paying promptly is paying for the delinquency of his neighbor. For these and other reasons, improvements should be made upon a cash basis, and the adoption of such a system is recommended as being the most economical and satisfactory.

The question of the method of payment having been settled by the authorities, and the improvements decided upon, I shall discuss them under their respective heads, first, however, recommending the establishment of permanent marks or —

STREET MONUMENTS

of some imperishable material, by which to locate the street lines.

The particular location of these monuments is not so material, so long as a uniformity is observed in locating them with reference to the center or side lines of the streets.

A good plan is to plant a cast-iron post at the intersection of the center lines of all streets crossing one another. The size and shape of one form of post used by the writer, is shown in the accompanying sketch (Fig. 1). Weight, 15 pounds; cost, whatever you can get the casting done for, usually three or three and one-half cents per pound, including the drilling of a small hole in the cap, to mark the center.

The monuments are quickly and easily set. The point at which they are to be planted having been found, they are then driven by a heavy iron maul with wooden faces, care being taken to drive them straight, and the monument being kept to the line of each street by glancing over pins which have previously been set on the center lines. After driving the monument a few inches below the surface, measurements should be taken to the most permanent objects accessible, and recorded, in a convenient form for quick and easy reference, in a book kept for that purpose, and designated "Monument Book."

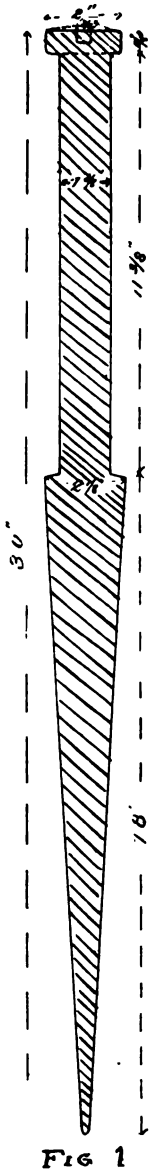

FIG 1

Street Monument

In recording the references, the writer uses an index book, indexing the east and west streets, and starting at the first street intersecting on the west, proceeding easterly, noting the streets in their order, to the east end of the street.

Each alternate page is ruled to five columns, leaving the intervening page blank for remarks; the last four columns on the first page are headed respectively "N. W.," "N. E.," "S. W.," "S. E.,' and refer to the direction in which the reference to the monument was taken.

The sample page given herewith, explains this more clearly.

HOYT.	N. W.	N. E.	S. W.	S. E.	REMARKS.
Water.....	....	47.9 f. post	.....	62.8 to br'k chim.	.....
Washington	....	59.4 f. post	.....	39.0 lamp post..	.....
Franklin...	45.8	28.65 basin	30.05 basin	46.55 bld'g	.....
Cass	....	.....	.....	.....	.....

Explanation: Hoyt St., which appears at the head of ths page, is an east and west street, and the index street, Water St is the first street intersecting with it on the west. The reference to the monument at the center of Hoyt and Water Sts., are: —

Northeast, 47.9 to fence post.

Southeast, 62.8 to brick chimney.

The location of these monuments should also be shown on plats in the office, which should denote the distance between the monuments and the angles made by the intersecting streets.

With these preliminary remarks, I will proceed to the consideration of —

STREET IMPROVEMENTS.

It has been said that "water is the greatest enemy which a roadway has to contend with," and experience has fully demonstrated that fact.

From the construction of the most primitive kind of road, to that of the most improved modern pavement, that fact should be kept in view, and the cardinal principle to be applied to them all is DRAINAGE, both surface and sub-drainage.

Whatever the particular quality of improvement to be made to a street, the first duty of the engineer is to see that proper provisions are made for drainage.

Some soils, as those of a gravelly nature, provide in themselves for perfect sub-drainage, but those of a retentive nature, such as clay, should be thoroughly underdrained by means of tile drains; if sewers have been constructed in the streets to be improved, good outlets for the drains can be had in them; but if not, some other method must be resorted to.

The matter of grades for the gutters of paved streets is another important point to be considered. Sufficient grade should be given them to carry rapidly the surface water to the nearest sewer basin, or other outlet provided for taking care of such water. Generally speaking, the minimum grade should be 4 inches per 100 feet, but this will depend somewhat upon the character of the improvement. A gutter paved with large, smooth flag-stones, requires less grade than one paved with cobble stone, or some other material offering greater resistance to the flow of water. The proper form of cross-section should also be considered. As in the case of grade of gutter, so with the cross-section, the greater resistance offered by the surface of the pavement to the flow of the water, the greater the crown that should be given to the roadway.

Taking, for example, a street to be paved with cedar blocks, as probably that class of improvement is the one most generally adopted in the cities of Michigan, the minimum grade, then, for the gutters, should be 4 inches per 100 feet, and the crown for a 30-foot roadway, 7 inches.

The following sketch (Fig. 2) shows a half section of a 30-foot cedar-block pavement.

PLANS AND PROFILES for an improvement should give all needed information. The title should indicate clearly what it is intended to represent. The plan should show width of improvement, location of tile drains, sewers, man-holes, basins, culverts, and all other fixtures. Profiles should show grade of finished surface, grade of tile drains, profile of surface of ground on center line, and the profile of side lines might also be placed thereon to indicate the difference between the grade at any particular point and the surface of the adjoining property; and further, the scale should be shown, as it is sometimes inconvenient to pick up a plan from which the scale as well as the measurements, etc., have been omitted. A small table placed in one corner of the plan, containing the estimated quantities of the material to be used in the improvement, is also of use to those examining the plans, and saves the engineer an endless amount of trouble in answering questions.

Make the plans of a uniform width, as they can then be more conveniently filed in a case prepared for them. A width of 14 inches will be found convenient; this will give plenty of room for plan, profile, title, and other information. The plan and profile being made to a uniform scale of 40 feet horizontal to 4 vertical, by cutting to this width, 42-inch paper can be used without waste.

Indicate upon the plans all changes and additions, if any, made during construction, at the time they are made, as "delays are dangerous," and the alterations are apt to be forgotten after the lapse of a few weeks.

Properly label and index all plans, so that convenient reference may be had to them.

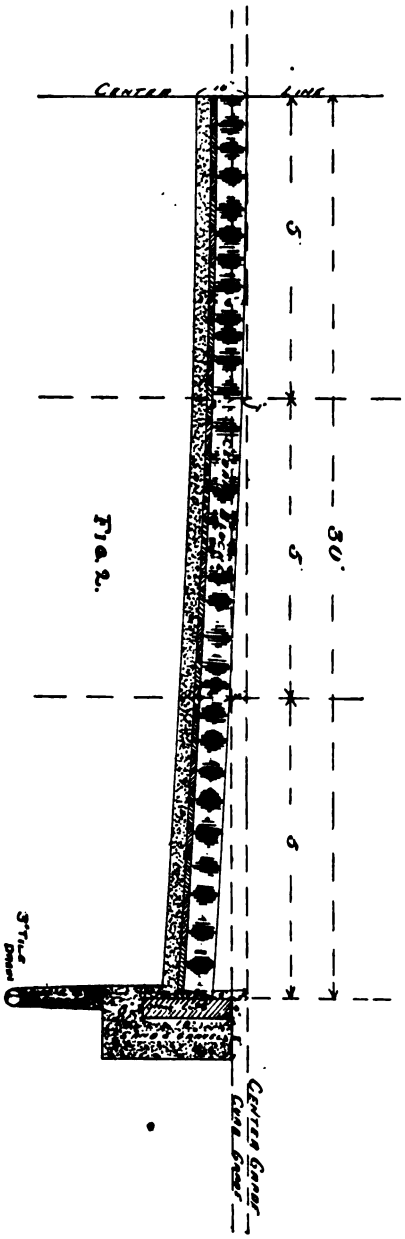

FIG. 2.

Half Section of 30ft. Cedar Block Pavement.

THE SPECIFICATIONS should be carefully drawn; and, as much as possible, cover every point that is liable to arise during the construction of the work, so that the bill of extras may be reduced to the minimum.

They should be full enough to cover every contingency which can be forseen, and yet should be brief, concise, and to the point. A verbosity of language should be guarded against, as it leads to confusion, and makes the meaning less plain than would a shorter, clearer style. Describe plainly the method of construction, the kind and quality of the material to be used, and the method of measuring the work.

The specifications, in fact, should indicate in good, plain English just what is intended to be done, and nothing else.

CONSTRUCTION. — It behooves the engineer to see that proper and constant supervision is given to the work during its construction, as upon it depends largely the faithfulness with which the work is executed. For this purpose, a person properly qualified to judge of the merits of the material and workmanship, should be kept constantly upon the work, and he should receive his instructions from, and report direct to, the engineer in change.

In many municipalities, the power of appointing such an inspector lies with the Board of Aldermen, who usually make their appointments solely upon political grounds, and without reference to the qualifications of the persons to fill the positions to which they are appointed. This, of course, is wrong, and to the detriment of the corporation doing so. The power of appointing or discharging inspectors for public works should rest entirely with the engineer. In fact, after the contract has been let, the engineer should be given entire and unrestricted charge, and he alone should be held responsible for its faithful execution, and for the acts of his subordinates.

CARE AND MAINTENANCE OF STREETS. — In the case of earth streets, the road-bed should be kept well rounded up, and all ruts filled in so as to prevent the water from standing upon and saturating it. In some places the habit prevails of depositing rubbish, old cans, chips, and the rakings from the back yard, upon the streets. This should be prohibited by proper regulations. Ashes, especially coal ashes, are not detrimental to a road, but rather an improvement, as a road-bed formed of this material presents a hard surface, and is less liable to form ruts during wet weather. The side ditches should be constructed to a true and uniform grade, and kept free from rubbish, that the surface water may rapidly pass to the outlet provided for it.

It is frequently difficult in a flat, level country, with a clay subsoil, to prevent water from standing and stagnating in the street ditches. In such cases, tile drains placed two to three feet below the bottom of the ditches will overcome that difficulty, the bulk of the water passing over the surface to the outlet provided; the remain-

der, which usually remains to stagnate and pollute the healthfulness of the city, will find its way into the drains, thus leaving the ditch in a clean, sightly condition.

The benefits to be derived from tile drainage cannot be overestimated. The system not only greatly increases the healthfulness of the city by lowering the water line in the soil, but it drains and permits an earlier use of the road-bed in the spring of the year, by carrying off the water caused by rain storms and melting snow and ice, instead of permitting it to remain and accumulate. In constructing tile drains, care should be taken to provide good outlets, as upon this depend largely their efficiency.

The cost of these drains is not great, ordinarily three-inch tile is sufficient, where it is unnecessary to go far for an outlet. The tile can be laid at from 60 cents to $1.00 per rod; the manufacturer's list price is $17.00 per 1,000 feet. Usually, a discount from the price list, of 10 per cent and better can be secured, for the tile delivered on the line of the work. Three-inch tile, therefore, purchased at 10 per cent off list price, and laid for 75 cents per rod, will cost, complete, about $1.00 per rod, and a corporation cannot invest its money to better advantage than by the construction of tile drains.

PAVED STREETS should be kept clean and free from dirt. The frequency with which the streets should be cleaned, will be determined by the uses to which they are put. Cleaning may be done by days' labor or contract; either by hand, with brooms and shovels, or, in dry weather, with a street sweeper drawn by one or two horses, men and carts following behind the sweeper to take up and cart away the sweepings.

The impression a stranger receives upon his first visit to a city, depends very materially upon the appearance of its streets. A dirty street is not only unsightly, but unhealthy, as the accumulation of dust and dirt becomes saturated with the urine of horses, and other offensive matter, which is given off in noxious vapors during warm weather.

Ruts, holes, and depressions in a paved street, should be repaired as soon as discovered. The old adage of "a stitch in time" applies here with much force. A small hole or depression, left to take care of itself, will rapidly increase in size, until what could have been repaired for a few cents at first, will cost many times that amount to replace in good condition.

SEWERS. — Having had a general plan prepared, it only remains, as any particular sewer is ordered to be constructed, to prepare detailed plans and specifications for the work.

The remarks made relative to plans, profiles, and specifications for street improvements, will apply with equal force here. The plans should show, not only the location of the sewer, but all manholes, basins, connections, etc., and upon the completion of the sewer, all connections and branches should be located with refer

ence to some permanent object. A convenient way is to show upon the plan the distance between each branch or connection and a man-hole. Branches for private connections should be placed in the sewer every 25 or 30 feet apart. Construct catch basins where required, usually at each street corner, as the basins will then take the drainage from the gutters of both streets; but the location of the basins will depend somewhat upon the established street grades. The basins should be constructed of sufficient size to catch and retain the bulk of the dirt and rubbish washed in from the street. The basins used in East Saginaw are constructed of 8-inch brick walls, 3½ feet in diameter in the clear, and 8 feet in hight, with the outlet into the sewer, 4 feet above the bottom. The basins should be cleaned each year, after the spring rains, or oftener, if required.

In their construction, too much care cannot be taken to lay the sewer to a true and uniform grade; the joints of pipe sewers should be well cemented, and the inside of each length of pipe cleaned as soon as it is laid, otherwise obstructions will be formed by the cement which may be flushed through the joints, around which accumulations of sewage will form, and cause stoppages in the sewer.

For the inner ring of the invert of brick sewers, the hardest and smoothest bricks should be selected, and each joint neatly struck, so that as little resistance as possible may be offered to the free flow of the sewage.

All brick for sewers should be inspected, and the soft bricks, and bricks containing lime, rejected. In warm weather, the brick should be thoroughly saturated with water before being used. This will prevent the absorption by the brick, of the moisture from the mortar, and will also readily detect the presence of lime.

The mortar box should also be closely watched, especially if the contractor furnishes the cement. The best plan is for the city to furnish the cement, as it is then certain of securing a more uniform article, and there is no inducement for the contractor to mix poor mortar; but entire reliance should not be placed in the manufacturer. The cement should be tested before being used in the work. Short-time tests may be made which will indicate in a measure the value of the cement. Tests should be made for fineness and tensile strength. The report of the committee of the American Society of Civil Engineers, "on a uniform system for tests of cement," presented at the annual meeting of that society in 1885, and which may be found on page 388, Vol. 14, of the *Engineering News*, contains a fund of useful information for making these tests. Gillmore's "Limes, Hydraulic Cements, and Mortar," is also a valuable work on this subject.

In mixing the mortar, the proper proportion of cement and sand (usually 2 of sand to 1 of cement, when natural American hydraulic cement is used) should be placed in the mortar box, and the two thoroughly incorporated before the water is added, other-

wise the mortar will not be of uniform quality, some portions being richer in cement than others.

The mortar should be used in the work as it is mixed, thus securing the first set of the cement in the masonry.

If an inspector is necessary on street improvements, it is much more important to have one on sewer work, as sewers are buried beneath the surface of the earth, and defects in material and workmanship not detected before they are covered, are liable to remain undiscovered until some portion of the sewer fails, when a large expense is entailed in making repairs.

For an inspector of brick sewers, an intelligent, competent mason should be employed, as he understands "the tricks of the trade" better than one who has had no special training in that line, and can more readily detect bad workmanship.

In connecting lateral sewers with the mains, the laterals should be constructed on such a curve that the flow from the lateral will be discharged in the direction of the flow in the main, otherwise an eddy will be formed in the main sewer, which will invariably cause a deposit, and consequently an obstruction.

Construct man-holes at all changes in the alignment of the sewer, and as much oftener as may be found necessary for proper inspection and care. In the case of pipe sewers (12-inch and over), man-holes from 150 to 200 feet apart will usually be found sufficient; while for brick sewers, it will not be found necessary to place them as close together as for pipe sewers.

CARE AND MAINTENANCE. — Sewers should be kept as clean and free from deposits as possible. For this purpose, occasional flushings should be resorted to, or flush tanks, located at the head of the lateral sewers, and discharging at regular intervals.

The outlets, if discharging into running or other water, should be placed sufficiently above the normal level of the water to insure their free and unrestricted discharge. When a sewer starts below or partly below the surface, the capacity of the sewer is decreased by the area occupied by the backwater from the lake or river, and the sewage coming from above, and discharged into this slack backwater, is there deposited, and so much of the sewer occupied by this backwater then becomes an elongated cess-pool, and an active factor for the manufacture of sewer gas.

The growth of willow trees should not be permitted in the vicinity of sewers, public or private. Experience has demonstrated that the two cannot live harmoniously together. The roots from the trees, if unrestricted, will enter, and in a short time completely fill, the sewer. To illustrate: In the summer of 1885, a 12-inch pipe sewer was constructed in one of the streets of East Saginaw. The pipe was laid at a depth of about 11 feet, in a stiff yellow clay soil; on one side of the street grew three medium-sized willow trees. During the past season this sewer was removed, to make room for a large main sewer; and, upon taking

out the pipe of the old sewer, it was found that the roots from these trees had entered the pipe, and a mass of roots, somewhat resembling a piece of cocoanut matting, 75 feet in length, 2 inches thick, and 15 to 18 inches wide, was removed from the sewer.

Many other instances of a like nature have come under the observation of the writer. In some cases, the sewers have been completely filled with the roots, necessitating the removal of the sewer, and the destruction of the trees.

In conclusion, it may be well to offer a few general —

REMARKS.

The quality of the improvements to be made in the streets of a young city, will depend very much upon its natural resources, and the first improvements will be made with a view of reducing the first cost to the minimum. The city with age and population, will demand something better, more durable, and of necessity more costly, than that first adopted; and in time will probably go through the whole category of roads, from a cheap gravel or planked road to that of one of block stone or asphaltum.

Michigan having such an abundance of timber suitable for pavements, naturally that material is used very extensively for the improvement of the streets of its cities. Cedar seems to be the timber now most generally adopted for the better class of wooden pavements, but owing to its lack of durability (which is also true of any wood pavement), it is really one of the most costly which can be constructed.

Many of the eastern cities, notably Washington, D. C., have practically abandoned the use of wood, and are adopting other materials.

Washington, which previous to 1879 had over thirty-four miles of wooden block pavements, costing over $4,000,000, has quite abandoned its use; and has now almost entirely replaced the old pavements with stone or asphaltum.

Sanitarists protest strongly against the use of wood for paving, as being injurious to health, and with very good reason; wood being of such an absorbent nature, readily retains the liquid filth from the street, to be given off, during warm weather, in odors offensive both to the senses and to health.

But the fact is apparent that, so long as wooden pavements can be constructed so much more cheaply than those of a more durable and less objectionable kind, just so long will wood be used, yet in the construction of the pavements and the selection of the material, care should be taken to make them as durable as possible.

Cedar, as most generally used, is stripped of its bark, cut into suitable lengths, and placed upon the foundation prepared to receive it, retaining all the sap wood, the portion quickest to decay, and the portion which most readily absorbs the filth of the street. Remove the sap, and you remove the most objectionable part of the wood.

Experience has shown that the life of a pavement, constructed of *sapless* cedar blocks, is longer, and that the surface wears smoother and more uniform, than when the sap is left on; for the sap wood being first to decay, hastens the destruction of the rest of the block. Then again: the blows from the wheels of passing vehicles wear away the sap more rapidly than any other part of the block, thus forming depressions in which to hold the water and wash of the street, to be absorbed by the blocks, and giving to the whole a rough, uneven surface over which to ride.

It was the intention of the writer to dwell somewhat upon matters pertaining to sewerage and other municipal works; but this paper has already exceeded the limits originally assigned to it. One word more, however, to the engineers here assembled.

Remember, our calling is not only of an executive nature, but it is more exalted than that. If we do not administer directly to the moral welfare of our fellow-men, we should at least contribute to their physical well-being. We can do this by example as well as by precept. Convince him of the unsanitary conditions of his surroundings, and indicate the remedy; show him wherein the pollution of his supply of water for domestic uses lies, and how it leads to physical debility and death. By continuous and untiring efforts in the right direction, much can be done to improve the condition of those who live in our respective communities.

A man has never attained to his most exalted position until he ceases to be selfish, and works for the improvement and elevation of others.

JOHN J. GRANVILLE.

Prof. Carpenter. — "I found at Memphis that their sewer system has not a good reputation at home. They have flush tanks at the heads of the small laterals. They use the Fields flush tank, which is a simple affair, consisting of a siphon arranged at the side of the vessel, the water going out with a rush. They report it as somewhat uncertain in its action. The siphon does not always act, so that the water, instead of going out with a rush, goes out at the same rate that it comes in. The city engineer reports that the use of a tilting trap, and an inside lip which reduces the size of the siphon, will cause it to act."

Mr. Appleton. — "Is there a deadener to this trap? They used the tilting traps in London years ago, and the noise of them was a great nuisance."

Prof. Carpenter. — "It is not needed, being below the street."

Mr. Appleton. — "There is a trap in this city having a movable bottom, which I put in several years ago, that has worked well, and never failed. It is not automatic, nor intended to act as an intermittent flushing trap. We do not put in a brick basin, because cement pipe is cheaper, and just as good. It is one thing that a cement pipe is good for."

Prof. Carpenter. — "Has Mr. Granville had any experience in the use of brick for pavement?"

Mr. Granville.— "I have not. I have received reports from Ohio engineers in regard to it, and samples of the brick used. It was not a vitrified brick. The trouble with brick pavements seems to be in the proper selection of the brick, to get them of a uniform quality. Some engineers retain a percentage until the pavement has been tested by one winter's frost."

Mr. Appleton — "If ground slate is mixed with clay, it makes it perfectly durable, but the trouble is in a false economy which will not pay for the best."

Col. Muenscher. — "Some cities require a good deal of blue clay in the brick."

Mr. Appleton. — "There must be a good deal of sand in a good brick, but it must also contain other material."

Prof. Carpenter. – "I saw a good many samples of brick at the brick-makers' convention. I think we have no clay in Michigan suitable for such brick. They must be very hard, dense, and not vitrified. A vitrified brick is not so strong as one which is not. In Cleveland, brick is as cheap as wood, and it can be laid down in Detroit as cheap. They have good brick in Ohio."

Mr. Watkins. — "In a sanitary point of view, is not the vitrified brick the best, being less absorbent?"

Prof. Carpenter. — "I do not know as there is any difference."

President Steele. — "I think we had better drop this part of the discussion here. We shall have the topic up later, in the paper from Prof. Greene. Have we anything in regard to other kinds of pavement, say of wood? In Traverse City, the streets are underlaid with sand. I don't know how deep. We have a pavement there which is a compromise between a stone pavement and a gravel road. The gravel packs very hard, and is very successful. We have plenty of cedar right at hand."

A. L. Reed. — "What sort of foundation is best for a block pavement?"

Mr. Granville. — "It is best to put boards under blocks. The first block pavement we had in East Saginaw was put down without boards, and the blocks went down unevenly. We roll the streets with a ten-ton roller, put on three inches of sand, and then cover with inch boards."

Pres. Steele. — "At Grand Rapids, they have cedar blocks on a gravel bed well rammed down, and covered with nothing but gravel well rammed. They have excellent drainage That may have a decided effect on the durability of the pavement, and speaking of that, if you want a durable plank, take one that has been in the mortar bed."

Col. Muenscher. — "This system was introduced into Grand Rapids sixteen years ago, when I was city engineer, and I believe it is the best there is. You must have a good foundation. Excavate a foot in depth, and fill it with gravel, not sand. The blocks in this foundation have stood ten years without displace-

ment. Leave the boards out when you have a clay bottom. The water runs through, and will rot the boards first. Then, too, the boards are always being cut and taken up, to make connections with gas, water, and sewer pipes, and can never be put back in good condition."

Mr. Granville. — "Right here is a point for criticism. In making sewer, gas, and water connections, the earth is softened. If boards are not put in, the blocks will go down. The boards will to a certain extent prevent that. If the blocks are well filled between with fine gravel tamped in, you have almost hermetically sealed the pavement, so that no water will go through. In East Saginaw we try to reduce the evils of taking up the pavement, by requiring people to make their connections the fall of the year preceding the paving of the street. If they wish to do it after the street has been paved, they are charged $25, to pay for the permanent damage to the pavement. We thus do not have much disturbance of the pavement. We take up a 16-foot section at a time, and never allow a board to be cut."

FREIGHT YARDS AND SIDINGS.

In looking over the reports of former meetings of this Society, I find several able and exhaustive articles on the location and construction of railways. There is, however, among others, one item which has been pretty much overlooked; that is, sidings and freight yards. They are not much thought of in the location of railways, and railway companies usually think that after a road is located and the main track laid, they can dispense with the services of most of their engineers; so the work is left to the trackmen, and the engineers are off to new construction. Consequently many of them have no experience in track work, and if by chance they are called upon to do such work, they are likely to commit blunders. This is one reason trackmen often have a contempt for engineer's stakes.

The locating engineer ought to have in mind the places where side tracks are likely to be put in, and then make the grades at such places as nearly level as possible. Serious accidents accompanied by loss of life have occurred from cars being started by the wind, and running out on the main track. This can be prevented by the stop-blocks in use on some roads, provided there is no neglect to put the blocks in place.

There should be as few switches as possible in the main track. Let the yard be developed from the side tracks.

There ought to be at least some attempt at uniformity in the laying out of the freight yards of any particular road. If there is a regularly organized engineer department, and the road master's

department is, as it always ought to be, subservient to the engineer department, there will be no difficulty in securing uniformity of plan.

Of course, yards will vary in the number and length of tracks, to suit local needs. This uniformity will conduce largely to economy and ease in handling traffic. If there is a plan determined upon before the yard is begun, the discovery will not be made that the freight house is located where there ought to be tracks, and that there are tracks where the wagon road ought to be.

There ought to be no open culverts or cattle-guards in the vicinity of freight yards or sidings.

Railway companies should care for the comfort and safety of their employees, even if they are not liable for damages.

The yards should be well lighted and well drained. Yard work is disagreeable and dangerous enough without wading ankle deep in mud or slush.

The blocks which are bolted in the throats of frogs, in the mouths of switches, and in the ends of guard rails, are useful in preventing men from catching their feet, and being thrown down and run over.

Some roads use a switch like the "Wharton" in the main line, and the split switch in the yard. Others use the common stub switch all around. Whichever is decided upon, let all the yards be similar, and brakemen will sooner learn the road, and in case of a strike, new men will the quicker become available. In staking out a siding or yard track, let not the engineer be too fussy. Now-a-days frogs are numbered according to the ratio of width to length, as 1 in 6, 1 in 10, commonly called No. 6 or No. 10. Methods are given in the various engineer's pocket-books for computing the distance from mouth of switch to point of frog. Suppose the engineer has found the distance to the end of the frog to be 58.97 feet. Let him stake it out 58 or 60 feet, for no track-man will cut a rail to humor his odd hundredths.

The remark is applicable which I once heard an eminent engineer make in reference to transit work. He said, "It requires a good deal of ability to know when to slight transit work." So I say it requires some judgment to know when to comform strictly to theoretical measurements.

In staking out a freight yard, the tracks are indicated by stakes on the center line with a tack in each. In large yards, to prevent confusion, the stakes may be painted a different color for each track.

The mouth of switch is indicated by a stake marked "M. S.," and the point of frog, by a stake marked "P. F."

The turnout curve may begin either at the mouth of the switch, or the heel. In the latter case, one end of the switch rails is spiked fast, and the curvature obtained by the movement of the switch rails. This makes the switch turn harder. It also changes

the "lead," or distance from mouth of switch to point of frog. In case it is required to turn out from a curve either inside or outside, the pocket-books give intricate formulas, but the following method, due to the late Charles H. Fisher, Chief Engineer of the New York Central, will answer as well:—

It has been shown that for practical purposes, the lead is nearly enough the same on straight lines as on curves. Now suppose that we wish to turn out from the inside of a 4° curve with a switch angle of 1° 20′, and a frog angle of 7° 10′. The lead, as may be found from the tables, or by computation, is about 58 feet. A 4° curve turns 2° 19′ in 58 feet. Adding the frog angle, 7° 10′, we have a total angle of 9° 29′. To meet this, we have the switch angle 1° 20′, and the curvature of the turnout. Subtracting the switch angle, leaves 8° 9′ to be turned by the turnout curve in 58 feet. This gives about a 14° curve.

In these days, when railways find it necessary to practice every economy, let not the freight yards be overlooked. It is just as easy and just as cheap, if the matter be taken in hand in time, to have a good, safe yard, as to have a poor, dangerous one.

O. C. GILLETTE.

Pres. Steele. — "I am glad to hear this paper from Mr. Gillette, and that he has given us in it a practical rule to work by."

Col. Muenscher. — "Very serious accidents sometimes occur from cars being blown from the side track to the main track. A simple and effectual preventative is to make the side track six inches lower than the main track. No wind can then blow a car from the side to the main track."

EVIDENCE OF FLOWAGE.

Mr. President and Gentlemen: —

THE surveyor is left to his own resources to a great extent in determining questions of flowage, and I shall not attempt to treat the subject here, as I am not the right man to do it, and shall be content simply to bring up the subject for discussion. To this end, I will give, briefly, the circumstances of a recent case.

By rights given under title of a deed, a dam was constructed entirely across the Kalamazoo River. The hight to which the right would raise the water, was definitely fixed by permanent bench marks on stone and tree. For a long term of years, this condition of affairs remained *in statu quo*. At last the requirements of civilization and more factories called for about two more feet of water, and with flash-boards that amount was easily obtained, often raising the water thirty inches above the prescribed right. The proof of these facts was permanent, clear, and undisputed. The

point denied was that although the water was raised unduly, it had no effect on fifty acres of land lying half a mile and more up the river.

The natural width of water was ten or fifteen rods. Above the dam, the water now spreads out to a width of twenty rods. The complaint of overflowed land commenced half a mile above the dam, and at this half-mile point, the water is six inches higher than at the bench mark, which is about eight rods above the dam.

An unmeasured line of levels was run from the bench mark along the river to the land, making there a bench mark at the same level as the old bench mark. The line was then extended and measured along the river and the land about 28 chains, and at suitable and convenient intervals, as many stations were made and lettered as was thought necessary. In this case, only six were made for fifty acres, as the land was not very uneven. From these six stations, cross lines were run due south; the river runs west, and levels were taken every eight rods. All these cross lines, that were needed to reckon the acres of wet land, were measured. The rest were paced, and with a few bench marks at H. I., this completed the survey.

Profiles and a map were made with contour lines of the land, showing, by small circles, the exact position of all the stations; in red ink, the hight of each station above the ice, and in green ink, the hight above the water of the river, when the water should be at its proper level, in this case, the hight of the dam, the dam being correct. Now comes in the question, What is a proper level at the land, under the circumstances? Is it the level of the dam? or should six inches be added to that level? or should still more be added? In other words, how much will water pile up under these conditions, and how much under other and dissimilar conditions?

A very important and separate set of river notes was kept, just as important to the purpose of survey, as the survey itself. The main purpose of the survey is to show the connection (if any) between the overflowed and wet condition of the land, and the raising of the dam with flash-boards. These notes show the exact position of the surface of the water, very early in the morning, of each morning, at the dam, and at the land, before the mills are started; also the surface at night, of each night, at the dam and at the land. The first morning a thin ice stuck to everything along the river, and remained two days. The water drew down three inches, at noon of the first day, at the dam, and two and one-fourth inches at the land. But the wind blew strong that day from the west, and up the river, and raised the water three-fourths of an inch at the land, because the water went down eighteen inches the next day at the land and dam alike. The second morning a heavy coat of ice formed one inch thick and about two inches lower than the first morning, two inches lower

at the dam and two inches lower at the land. At the latter place, ice formed entirely across the river, but not above there. Thermometer, 22°. At night of the second day, the water had gone down eighteen inches at the land, and just eighteen at the dam. The wind was now reversed.

Of course it is the peculiar province of the court and jury to say that these facts mean nothing, and show no relation between the dam and land, and the judge generally takes the trouble to point out to the jury that the Supreme Court of the State has decided that a surveyor's evidence is not the evidence of an expert, and that they need not give it any more weight than the evidence of anybody else. Nevertheless, these facts should all be noted fully, and written out with care, mapped, and submitted.

Ice does not always form just when you want it to, nor at all times of the year. But stakes can be driven at the dam and at the land, and water marks be made by pressing in tacks at the surface, at the times of high and low water, and as extended a record kept as possible and as the time will allow. Indeed, the date and hour can be written on the stake itself, and against each tack. Better still, at the land notches may be cut on saplings growing in the water. These notches may be referred to, in months and years to come, with confidence, when it shall be necessary to take more evidence, or to verify what has already been done, knowing that they cannot be driven down or raised by ice.

These water-sprouts and saplings present a new and important branch of evidence of their own; namely, that they never began life one or two feet under water, or even six inches. Hence the map can show a few places where sprouts are growing in the water, and show its hight above their union with the stump. This measure must be taken, in all cases, at the top of that union, as the growth is mostly on the lower side. There can also be marked upon the map the position of a few stumps standing in the water (if there are such), giving the size and kind of timber.

Another equally conclusive source of evidence of the facts required by the survey, may be given under the following conditions: When there are even a *few* spots of sand or fine cultivated loam along the edges of the high-water line, this line will be nicely marked, sometimes in one way, sometimes in another. Close and accurate marking will be found where a light dash of rain or snow or hail has printed all the exposed surface, while the sand, covered with water, will be smooth; and when the mill owners see the surveying party preparing for business, they are sure to draw off the water as fast as possible. At least such is always the talk, and the facts seem to sustain it. Then the surveyor can read, as he walks, the exact position of the high-water line, and as the water recedes, compare its positions, above and below. This printed line is far better than the water line itself, as the latter is continually changing, and is likely to

introduce an element of error, while the printed line will not move until covered with water, and will then stop again at some particular grade. E. STRONG.

Prof. Carpenter. — "There is one question raised in that paper that has been discussed a great deal before this Society, as to what constitutes the hight of a dam. Probably all the surveyors of Lansing have made extensive surveys to determine that question with reference to the dam at North Lansing. The Court refused to answer the question as to what constitutes the true hight of a dam, and decided the case entirely on the ground that the dam had been raised from its original hight, and must come down again, without regard to the actual hight of the dam. We do not know yet whether the head of water is to be measured from water below the dam to water above, or from the ground below the dam to the top of the dam, or in what way the true hight should be determined."

Mr. Hodgman. — "The point made in this paper, as I understand it, is in relation to fixed bench marks on the bank of the stream."

Mr. Appleton. — "Is it not rather how much the standing wave is? We know that this wave varies in different conditions."

Mr. Hodgman. — "The question raised, it seems to me, is. If we raise a dam a certain distance, will it raise the water in the stream above level with the dam, or will it raise it higher than the dam, and if higher, how much at different points in the stream above, and how will this affect the flowage?"

Mr. Appleton. — "It will do that. In the case here, the water was raised enough above the dam to be readily determined."

Mr. Watkins. — "Did you determine the hight with reference to certain fixed marks?"

Mr. Strong. — "Yes, sir."

Mr. Watkins. — "The point was once raised in this Society whether a stump is reliable for a bench mark, and it was decided that stumps cannot be depended on"

Mr. Strong. — "That might be true, but I think it has been sufficiently well determined that a tree will not vary in its hight, but each part retain its original level. This has been demonstrated by a large number of experiments. The bench marks in this case were made upon trees and boulders, and stakes were also driven into the water in some places to a certain depth below the surface, so that even if some of the bench marks were moved or destroyed, we would still have something left."

Prof. Carpenter. — "In the case of the North Lansing dam, I made the survey when the water was very high, and Mr. Appleton, when the water was very low. The standing wave from the dam, as I measured it, was reduced as you neared the head of the dam. I think when Mr. Appleton had two inches of high water, I had nearly two feet."

Mr. Appleton. — "The standing wave varies with varying conditions of the water, but I think we pretty well settled it."

Mr. Strong. — "Did you take into account the wind?"

Prof. Carpenter. — "This river is thoroughly protected from the wind."

Mr. Appleton. — "About four miles of it is through the woods."

Mr. Watkins. — "I know a dam is a dam with me."

President. — "I don't find it so. A farmer who thought he was terribly injured by a dam in Leelanaw County, commenced suit to take away a dam below him. The gentleman who owned the grist-mill that was situated on the stream, had to suspend operations, and went to a good deal of expense and trouble to find out the actual fall. The farmer claimed that the dam had raised the water in the lake, and had caused it to overflow the adjoining lands which he owned in that vicinity, and he was making every effort to abate the nuisance. It was tried in the Justice Court, and next in the Circuit Court for the county of Leelanaw, and I was called upon to take some observations and levels about there on the part of the owners of the mill. I found the hight of the standing wave very much to the astonishment of the opposing counsel, who could not see how water could be anything but level, or how a dam could actually raise the water above it, although, as I told them, it could be easily detected with the levels. But the point which secured the defendant's case was that happily there were four government meandering posts on that lake, and they were witnessed, and those witnesses were all perfect, and when I went there with a boat, I found everything all right, and that the original stakes which the government surveyors put in the swamp were perfect, although they were thirty or forty years old then, and they were exactly where they ought to be in every case. They found that the survey which I had made showed the water in the lake at the same hight as it was shown to be by the government surveyor, or a little lower, hence how could the dam have caused the rise of the water? The fact was that the rise in the stream had been caused by a large number of springs on the farm owned by the complainant, so that he really was the party to blame for the overflow, and not the defendant's dam. The point won the case. Of course, the leveling is very nice, and it was something they could not get around."

TESTS OF MICHIGAN WOODS.

THE last two winters I have had considerable opportunity to become acquainted with the methods of testing, first at Cornell University, and since at the College. The machine we have is arranged to take material up to a certain size, two and a half inches square or less, and the testing capacity is 50,000 pounds. The power is applied by means of a hydraulic press. This machine is arranged, as most of them are, so that we can test lengthwise, either in tension or in compression, and crosswise or transversely. Now, in testing material, we want to get the breaking weight and the elastic limit. There will be a certain stretch, up to which point it will go back to its original form, or nearly so. This is the elastic limit. Just where this elastic limit is, is really more important to know and to find out in our investigation, than how much it will take to break it. It is necessary, then, in order to determine that, to have some instruments by which we can measure the stretch of it, or how much compression it will stand in pushing it together. I have for this purpose arranged two little points which I place on two collars, between which I put a micrometer of the Brown & Sharpe pattern, and in this way I can measure the elongation. Now so long as this elongation is uniform, we are within our elastic limit; and so long as it keeps within the elastic limit, it will go back, or nearly back, to its original form. But a time comes presently when the stretch becomes greater, and instead of being one-thousandth of an inch, it increases to from two to sixty thousandths of an inch, and more. You will notice in the specimens that I have here that some of them look as though they had been tapered off, when actually they were just the same size before testing.

Here is a piece of tool steel about one-fifth of a square inch in area, which took actually 33,000 pounds to pull apart, being the strongest piece of steel I have ever tested. Here are some specimens of a bronze which is considered to contain about 5 per cent of aluminum, and here is a piece of common bronze. If you will look at this specimen, you will see the effect of the pulling. You will notice that this is drawn out of shape. Sometimes the piece breaks in a very queer way, and in pulling it out the tension causes it to open up in several places. Now, in testing woods, this much we have found out — and probably it is a well-known fact to all that are using woods — we can never get a fair tensile test of wood, on account of its being almost sure to give you a splitting break, rather than a square cross break. Woods are not fit materials to be used in places where tension is required.

For compression and transverse strains, wood works very well, and the results we get with our testing machine are very satisfactory. I have tested forty or fifty different kinds of wood. Hard

maple runs up the highest in transverse strain, having reached 18,924 pounds to the square inch. Among some other specimens I have tested, is white pine, which ran as high as 8,000 pounds, some specimens running a little below and some above. In some other reports I have the locust, as running highest, 17,000 to 19,000 pounds.

Wood is generally used in a frame or truss, either as a beam, or as a post or pillar. In the first case the effect of the load is to bend the beam, and finally to break it, where most bent, or close to the points of supports. The power of the beam to carry such a load, we term its transverse strength, limiting the term usually to the bending only, and using the term transverse shear when we refer to the strain next to the points of support.

Where wood is used as a pillar, the effect of the load is to compress or shorten it; if the pillar is less than about ten diameters long, the effect is generally to crush it, either by a wedge flying out from one or more sides, or by the doubling up of the fibers of the post. When the pillar is long with respect to its diameter, the effect of the load is to bend it, often into a complicated form. The theory of this last case is not a simple one, although within the elastic limit it seems to agree well with experiment.

Wood is sometimes used as a tie rod, in which case the strain tends to pull the fibers apart, or to lengthen the rod. Wood is poorly adapted for such strains, since the effect of cross-grain or knots or any defect whatever would be more seriously felt here than in the other cases. A large and uncertain excess of strength would in this case be needed.

Wood is sometimes used as a mere bearing block, in which case the effect is the same as a very short pillar.

The theory of action of forces on materials is treated at length in various works on the strength of materials, and can be studied exhaustively in such books. For the convenience of those who may desire to look the subject up thoroughly, I will mention a few works published by Wiley, as follows: Burr, "Strength and Resistance of Materials;" Lanza, "Applied Mechanics;" Church, "Mechanics of Materials;" Merriman, "Mechanics of Materials;" Wood, "Strength of Materials;" Thurston, "Materials of Engineering." The work by Burr is especially full of information.

For the convenience of those who may not have access to any of the works mentioned, I give a few formulas for the simplest cases. These formulas, probably, strictly speaking, will apply only when the load is within the elastic limit, but the results are in most cases nearly correct up to the breaking point. It is customary to figure the formula as correct up to the breaking point, and then take loads one-fourth or one-fifth the amounts given, as safe loads. By the elastic limit is meant that load which produces the first permanent deformation in the shape; it varies all the way from one-fourth to nine-tenths the breaking load, in different materials. In

testing the strength of materials, it is important to locate the elastic limit; the method of doing this is as follows: equal increments of load are added, and the resulting change of form is measured. So long as equal increments of load produce uniform deformation, the elastic limit has not been passed. When the deformation increases at a greater rate for the same increase of load, it is assumed that the elastic limit has been passed. This involves a very minute and accurate measurement, as the deformation in all cases is small, and a small error may make a considerable difference in the result. The approximation location of the critical point is the best that can be done.

Many experimenters do not believe in the existence of an elastic limit, but the discussion of that point does not come within the limits of my paper. The coefficient of elasticity is obtained by dividing the load per unit of area by the stretch per unit of length, at any point within the elastic limit. It is greater for the stiffer materials.

The following formulas represent the simple cases of breaking:—

For Tension:

$$P = FS$$

P = breaking load.
F = coefficient for Tension.
S = area square inches of cross section.

For Crushing:

$$P = CS$$

C = coefficient for crushing.
S = area square inches of cross section.

For Compression — Long rectangular columns square ends of wood:

$$P = \frac{F' S}{1 + \frac{1}{250}\frac{h^2}{l^2}}$$

F' = coefficient for compression long columns.
S = area in square inches.
l = length in inches.
h = least dimension in inches.

For Transverse — Beam supported both ends, load at center, Rectangular beam:

$$P = \frac{2}{3}\frac{b h^2}{l} T$$

h = depth in inches.
b = breadth in "
l = length " "
T = coefficient for transverse breaking.
P = breaking load.

For Shear:

$P = F' S$ in which F' equals the coefficient for shearing.

In all the above formulas:

P = breaking load.
S = area of cross section.
l = the length in inches.

The following results are in common use:—

TABLE OF COEFFICIENTS OF STRENGTH OF WOOD — FROM CHURCH'S MECHANICS OF MATERIALS.

	Elasticity.	Strength at Elastic Limit.	Strength at Breaking Point.
Tension	200000 to 2000000	3000 to 19000	6000 to 28000
Compression	.....	.....	.....
Short Blocks	350000 to 2000000	.....	2000 to 10000
Compression	.....	.....	.....
Long Pillars	.....	.....	7200 .....
Transverse	1000000 to 3000000	1000 to ?....	4000 to 20000
Shear { across grain	.....	.....	1500 to 8000
Shear { with "			500 to 1200

The tensile strength of woods is difficult to obtain experimentally, because of the liability of breakage by splitting instead of pulling the grain fairly apart. Any imperfection is especially manifest in this kind of strain.

I have made but few tests to ascertain the tensile strength of wood, and these gave results considerably less than the values tabulated in our works on strength of materials. As showing the method of making these tests, I submit the log of one test complete: —

TEST OF SEASONED HARD MAPLE 8.67 INCHES LONG, SQUARE CROSS SECTION 7-INCH AREA.

Load Shown by Testing Machine.	Micrometer Reading Inches.	Stretch in Inches.	Load per square inch.	Coefficient Elasticity.	Remarks.
0	0.486	0			
1000	0.488	0.0025	1428		
2000	0.490	0.0025	2857		
3000	0.494	0.0035	4285		
4000	0.498	0.0040	5999		
5000	0.503	0 0050	7143	3.753320	Near the Elastic Limit.
5500	0.511	0.0080	7857		
6000	0.5140	0.0030	8571		
6500	Rupture.		9285		Split and sq. break exposing 6 sq. inches.

The following are some values found for other woods : —

TESTS OF WOOD IN TENSION — SUMMARY OF RESULTS.

Kind of Wood.	Approximate Elastic Limit.	Breaking Strength.	Coefficient Elasticity.	Length inches.	Area sq. inches.	Remarks.
White Pine.....	2685	6712.3	671220	13.2	0.739	Round poor break.
Swamp Oak.....	3846	7692	1797663	7.0	0.526	
Black Walnut....	2978	6400	1240000	6.0	0.503	
Hard Maple.....	5999	9285	3753320	8.67	0.700	

LOG OF TRANSVERSE TEST OF SUGAR MAPLE.

Load applied at center 24 inches long, 2.9 inches deep, .86 inches thick.

Load Applied.	Reading of Micrometer inches	Total deflection at center inches.	Coefficient of Strain per square inch.	Coefficient of Elasticity.	Deflection per 100 lbs. inches.	Remarks.
0	0.921					Well seasoned specimen Rectangular cross section.
500	0.844	.077	2490		.017	
800	0.811	.110	3984	1199000	.011	
1000	0.781	.140	4980		.015	
1200	0.760	.161	5976		.0095	
1400	0.734	.187	6972		.013	
1600	.698	.223	7968		.018	
1800	.683	.238	8964	1246000	.0075	
2000	.659	.262	9960		.012	
2200	.624	.297	10856		.0175	
2400	.597	.324	11952		.0235	
2600	.558	.363	12948		.0195	
2800	.525	.396	13944		.0165	
3000	.480	.441	14940		.0225	
3200	.427	.494	15936		.0265	
3400	.367	.554	16932		.030	
3600	.284	.637	17928		.0415	
3710	Broke.			18924		

It is to be noticed that the deflection, although somewhat irregular, remains about constant, until the load is greater than

2,000 pounds, in which case the coefficient is 9,960 pounds per square inch.

I found accidentally that a very complete determination of the transverse strength, and various other properties of woods, had been made for the tenth census reports of the United States. These determinations were made for Prof Seargent by Stephen P. Sharples, of Cambridge, Mass.

In the results as published, all dimensions and results are expressed in French measures. The specimens for transverse strength are uniformly of a square cross section, each side being 4 centimeters. In breaking, the specimens were vertical and the force applied horizontally. For crushing, the blocks were uniformly 32 centimeters high and 4 centimeters square.

The specimens were all thoroughly air dried, and the weight in pounds per cubic foot is given.

The fuel value was obtained by actual combustion with an analysis of the resultant products; the results are expressed with an arbitrary series of numbers, the fuel value being in proportion to the numbers.

The number of specimens of each kind varied from five to fifteen.

Thinking these results might be useful if put in an available form, I reduced the average result of each species to English measures, and have arranged in the following table the properties given for all the native specimens known to grow in our own State. These results are so full and complete as to make it entirely needless to publish the meager results of my own tests. I give, however, the log of one test for transverse strength, to show the method of testing, rather than to give information as to the results.

PROF. R. C. CARPENTER.

Mr. Watkins. — "How do you find swamp oak, as compared with other woods?"

Prof. Carpenter. — "Swamp oak is not as strong as hard maple. It runs, I believe, about 14,000 to 15,000 pounds per square inch."

Mr. Watkins. — "Among mill men I believe it is considered the stiffest timber for shafting."

FROM CENSUS REPORTS — REDUCED TO ENGLISH MEASURES.

Woods of Michigan.		Weight per cubic foot, pounds.	Approximate fuel value.	Coefficients of			
Botanical Name.	Common Name.			Elasticity.	Ultimate Transverse.	Longitudinal Crushing. Pounds per square inch, 8 diameters high.	Resistance to indentation. ½ in. depth per sq. inch.
Liriodendron Tulipifera	White Wood — Tulip Tree	26.36	63.26	1283000	6797	5520	1120
Asimina Triloba	Paw Paw	24 74	39.61	663000	5560	3615	900
Tilia Americana	Basswood Linden	28.20	45.00	1183000	8374	4875	890
Xanthoxylum (Colden) Americanum	Prickley Ash	35.23	50.15	1035000	9115	6175	1130
Acer Saccharinum	Sugar Maple — Rock Maple	43.08	68.75	2064000	16225	8670	3400
Acer Nigrum	Black Sugar Maple	43.09	68.66	1043000	13679	7470	3500
Acer Dasycarpum	Silver or White Maple	32.84	52.52	1560000	14590	6650	1540
Acer Rubrum	Red or Soft Maple	38.50	61.65	1335000	11634	6400	1360
Negundium Aceroides	Box Elder — Ash-leaved Maple	26.97	47.95	800000	7522	4370	1480
Rhus Copallina	Dwarf Sumach	32.86	52.42	1030000	9427	5200	1465
Rhus Venenata	Poison Sumach	27.31	77.28	1485000	9314	7960	2800
Cercis Canadensis	Redbush — Judas Tree	39.65	63.18	985000	10689	6460	2460
Gymnocladus Canadensis	Kentucky Coffee Tree	43.21	68.88	1485000	10977	5520	2170
Gleditschia Triacanthus	Honey Locust	42.00	66.86	1535000	13124	6950	2240
" Monosperma	Common Locust	45.76	72.89	1670000	17087	8150	3790
Prunus Americana	Wild Plum	44.96	72.02	1173000	9460	8200	2900
" Serotina	Wild Cherry	36.28	58.14	119400	11160	7560	2750
Pyrus Coronaria	Wild Crab Apple	43.92	70.11	893000	6630	5775	3400
Amelanchier Canadensis	June or Service Berry	48.85	77.95	1695000	16000	9430	3860
Cornus Florida	Flowering Dogwood	53.81	80.98	1153000	12790	7360	4250
Nyssa Multiflora	Pepperidge — Black or Sour Gum,	39.59	63.66	1150000	11630	6470	2640
Fraxinius Americana	White Ash	40.77	65.16	1422000	10520	6460	2260
" Pubescens	Red or Downy Ash	38.96	62.35	1134000	9840	6050	2770
" Quadrangulata	Blue Ash	46.78	74.50	1090000	9120	6870	2750
" Sambucifolia	Black Ash	39.37	62.72	1090000	11300	5770	2630
Sassafras Officinale	Sassafras	31.42	50.38	709000	5510	5250	1770

Ulmus Fulva	Slippery Elm	43.35	69.77	1340000	13160	7520	1950
" Americana	American or White Elm	40.54	64.54	1070000	11200	6220	2530
" Racemosa	Rock or Cork Elm	45.26	72.20	1550000	15520	8250	2760
Celtis Occidentalis	Hackberry — Nettle Tree	45.41	72.08	970000	9150	5780	3650
Platanus Occidentalis	Buttonwood - Sycamore	35.38	56.52	1225000	8770	6230	2240
Juglans Cinerea	Butternut	25.46	40.66	1450000	8230	5450	1240
" Nigra	Black Walnut	38.11	60.91	1545000	9750	8000	2640
Carya Alba	Shagbark Hickory	52.17	83.11	1980000	16970	9820	3680
" Sulcata	Western Shagbark Hickory	50.53	80.35	1462000	13600	7770	3910
" Porcina	Pignut Hickory	51.21	81.36	1423000	14320	8100	4140
" Amara	Bitternut	47.06	74.74	645000	13170	7200	3320
Ostrya Virginica	Ironwood	51.62	82.42	1936000	17780	7530	3100
Carpinus Caroliniaria	Blue Beech	45.41	72.26	1631000	14200	6880	2900
Quercus Alba	White Oak	46.35	74.39	1373000	10330	7070	2880
" Macrocarpa	Burr Oak	46.45	74.06	1310000	8990	6800	3150
" Bicolor	Swamp White Oak	47.75	76.18	1273000	9570	6800	2970
" Prinoides	Yellow Chestnut Oak	53.63	86.09	1590000	18380	8020	3600
" Nigra	Black Jack Oak	45.64	72.39	1370000	14900	6880	3940
" Rubra	Red Oak	40.75	65.28	1608000	11940	7100	2380
Castena Vulgaris	Chestnut	28.07	44.95	119500	8053	5240	1420
Fagus Ferruginea	Beech	42.89	68.48	1716000	17460	6540	2630
Betula Lenta	Black Birch — Sweet Birch	47.47	75.97	2200000	17160	8670	3070
" Luta	Yellow Birch	40.84	65.34	2280000	17600	8670	2170
" Papyracea	Paper or Canoe Birch	37.11	59.40	1800000	14950	6750	1700
Populus Tremuloides	Aspen or Poplar	25.13	40.10	1145000	9430	4560	1040
" Monilifera	Cottonwood	24.24	38.53	1405000	10830	4680	1060
" Balsamifera	Balsam Poplar	22.65	36.11	1200000	7630	4440	1000
	Balm of Gilead	25.93	41.42	1033000	8230	3760	860
Thuja Occidentalis	Arbor Vitæ — White Cedar	19.72	31.53	727000	8730	4110	770
Juniperus Virginiana	Red Cedar	30.70	49.11	945000	10360	5860	1940
Pinus Strobus	White Pine	24.02	38.47	1195000	9220	5560	970
" Resinosa	Norway Pine	30.25	48.41	1595000	11320	6370	1100
" Banksiana	Jack Pine	29.67	47.50	1325000	9100	5470	1340
Picea Nigra	Black Spruce	28.57	45.71	1555000	11450	5660	1020
" Alba	White Spruce	25.25	40.38	1440000	11465	4720	960
Tsuga Canadensis	Hemlock	26.42	42.20	1280000	10900	5240	1100
Abies Balsamea	Balsam Fir	23.80	38.02	1150000	7000	5030	1000
Larix Americana	Tamarack	38.86	62.16	1790000	9450	7600	1400

BRICK STREET PAVEMENTS.*

As towns grow into cities, and their street traffic increases, pavements become a necessity.

In parts of Illinois, where timber is scarce, and stone and gravel almost wanting, hard-burnt bricks have been used for paving, and the cheapness of the material has commended its use to the people.

In Bloomington, Ill., fifteen years ago, a courtway was paved with bricks as an experiment, and this courtway, exceptional for a first experiment, is still in a fair condition, after scarcely any repairs.

Bricks fit for paving are so different from common bricks, that we have thought some facts about the former might be interesting.

Clay which will make good paving bricks should be able, without fusing, to withstand a sufficient degree of heat, and for a long enough time to render the bricks hard and impervious to water. Yet, while the value of a clay for paving brick depends largely upon its refractory nature, fluxing agents, in proportions yet undetermined, are necessary to render the bricks homogeneous and tenacious.

Fire clays are generally hydrated silicates of alumina. Potash, soda, lime, magnesia, iron, and other elements are sometimes present in small quantities, and render the clay less refractory the greater the quantity of them present. When 6 to 10 per cent is found, the clay will generally melt. When the clay is siliceous, 3 to 4 per cent makes it fusible. When it is aluminous, 6 to 7 per cent of oxide of iron does not render it non-refractory, because aluminites are mostly of a refractory nature.

Lime alone is completely infusible; but in very small quantities in clay, it makes a brick fusible at high temperatures. It is especially to be avoided in clays for paving-bricks, because the heat of burning reduces the carbonate to caustic lime, which in the pavements will absorb moisture and cause disintegration of the brick.

Magnesia in small quantities is said by Egleston to make clay fusible.

The alkalies, from 1 to 3 per cent, make clay fusible.

The change of color in burning is due to iron, or to a small percentage of bituminous material. Iron, beyond 6 to 10 per cent, if the clay is siliceous, usually renders it fusible.

Silica and alumina constitute the refractory parts, and the impurities the fluxing part.

Silica is infusible alone, except at the highest temperatures of the oxyhydrogen blow-pipe. It possesses no binding property,

*Cordensed from a thesis by Mr. Edgar Ryan, University of Michigan.

and a clay having an excess of it is rough, and lacking in plasticity and tenacity, thus rendering the bricks weak.

Alumina is highly refractory and is binding. When combined with iron or other bases alone, it makes infusible aluminites; but with silica present, it fuses more or less readily.

The plasticity of clay is due to the fineness of the particles, to the presence of alumina, and to the water of combination, which may be driven off at a red heat, the clay losing its power of combining with water.

The refractory nature of a clay is then due to the presence of alumina and silica in excess, and to the absence of potash, soda, lime, magnesia, and iron.

The characteristics of all fine clays may be said to be, that they do not effervesce with acids; that they make a paste with water, which paste can be drawn out without breaking, and is very plastic; that when dry they are solid, and break into scales when struck; have a soapy feeling, are easily scratched or polished, can be cut into long ribbons with a knife, and appear somewhat like horn.

The commercial test is the only sure way of ascertaining the value of a clay.

Some clays which we will mention have been used more or less successfully in making a paving material.

"MINGO" FIRE-CLAY, HAYDENVILLE, OHIO.

The clay from which the Hayden patent Paving Block (of which a sample is submitted) is made, has nearly the compactness and density of fine-grained sandstone, and yet is semi-plastic. It can be characterized neither as a hard nor as a plastic clay. Nitroglycerine is used in mining it; yet, while apparently very hard, it is readily reduced to powder in the dry pan under heavy rolls. The clay when ground is excellent for laying fire-bricks, mixing easily, working smoothly, and resisting great heat.

The paving block in burning is subjected for ten days to 2,000° F.

This paving block is square in plan, 5¾ inches on a side, and 4¾ inches deep, hollow below to facilitate burning and save material, and having a flat upper surface broken by indentations intended to provide a firmer foothold for horses. These indentations, however, seem to be of little permanent value, as under heavy traffic they are soon obliterated. The blocks are salt-glazed. The outer top edges are slightly beveled, to admit readily a filling of sand, pitch, or other material in the joints after laying. One thousand blocks will lay 26 sq. yds., at 50 cts. per hundred, or $1.92 per sq. yd. The sidewalks are 1⅛ inches thick and top 2 inches. The endurance of the block is therefore limited to the wear of the top. A block weighs about 9½ lbs., giving about 360 lbs. to the sq. yd.

An analysis of this clay, by Prof. E. M. Reed, is subjoined, and a comparison is made with the well-known Stourbridge clay of England.

	Mingo Fire Clay, Haydensville, Ohio.	Stourbridge Fire Clay.
Silica	72.24 per cent.	73.82 per cent.
Alumina	16.87 "	15.88 "
Iron	0.16 "	2.95 "
Lime	0.50 "	trace
Magnesia	trace	trace
Alkali	1.09 "	0.90 "
Water	5.44 "	6.45 "
Total	100.00 "	100.00 "

PAVING BRICK CLAY, VIRDEN, ILL.

This clay is found in a bed 25 feet thick, lying just beneath a stratum of slate, and 275 feet below the surface of the ground. It is compact, with a distinct cylindrical cleavage, of a light steel-gray color, and emits, when first mined, a characteristic odor resembling that of slate. Although it is blasted out, it has only the hardness of soft slate, and can be reduced to an extremely fine powder free from grit. It has a specific gravity of 2.5595. A piece kept at a white heat in a hard coal fire for twelve hours, was not disintegrated, and concentrated nitric acid failed to produce effervescence.

It is reduced to powder by being first passed through a Blake crusher, then finished in a dry pan crusher. The process is imperfect, as particles of uncrushed clay weighing as much as fifty milligrams have been taken from a green brick. These particles had not apparently been affected by the water used for tempering, and they remain intact through the process of burning, being easily discerned in a burned brick, and rendering it heterogeneous. When tempered with water, the clay becomes plastic, tenacious, and firm, being readily formed into different shapes. A sample is here submitted.

CLAYS FROM BLOOMINGTON, ILL.

These may properly be called "surface clays," and are of three varieties.

"A" is a yellow, aluminous clay, very fine and plastic, found three feet below the surface, in a bed 12 feet in thickness. It is subjected to no process of grinding or reduction, being simply tempered in a vertical pug-mill directly from the bank. It burns to a grayish-red color.

"B" is a hard-pan clay just beneath the "A" layer, and from one to one and one-half feet thick. Great difficulty is experienced in reducing this clay to an impalpable powder. When dug and exposed for one winter, to "weather," or disintegrate, very good results are claimed for it. But when this clay is reduced at once, uncrushed particles occur which cause unequal shrinkage in the

burned brick, leaving small cavities where, in the pavement, water may accumulate and cause disintegration by freezing. Hard-pan clay generally burns from pink to cream in color.

"C" is a blue clay directly beneath the hard-pan clay, and has a depth of from one to six feet. It is plastic or semi-plastic, fine, firm, and very tenacious, and usually burns to a chalk white. In many respects it is similar to the light blue fire clay used for fire and paving brick at Empire, Ohio.

From the experience of the best manufacturers of paving brick, we are led to conclude that fineness of grain in clay is most essential, and where that property is found in a plastic clay, provided the clay is sufficiently refractory, care only is needed in tempering and burning, to produce good results. When fine-grained clay has a compact and hard structure, no pains should be spared to reduce it, in a dry state, to an impalpable powder.

Where the clay is neither dry nor fine, but of desired composition, it may be calcined and then finely ground. This may appear a trivial matter, yet, if two samples of the same clay are ground, the one finely and the other coarsely, the latter will require much more heat before vitrifying to a homogeneous mass; while the more finely it is ground, the stronger and harder the bricks will become, the better they will stand abrasion, and the less liable will they be to break.

THE MANUFACTURE OF BRICKS.

The great diversity in the clays makes the process of manufacture a difficult problem, for the experience gained in one place may be of little or no use in another.

In several towns, notably Ottawa and Virden, Ill., manufacturers use the plant commonly employed for making tile, modified for bricks. At Virden, Ill., where the capacity is 1,600 per hour, the process is in substance as follows: —

The clay hoisted from the mine, is delivered from tram-carts to a Blake crusher, and then finished in a dry-pan crusher. It is then delivered to a tempering machine, and forced from the latter by a screw through the desired mold, whence it issues in one continuous bar, 8½ inches by 4¼ inches in a section. It runs over a series of rollers, and is cut up by wires spaced two inches apart, in a hinged frame worked by hand. The bricks are removed on tram-cars to a dry-house or shed, and left until sufficiently dry. They are then placed in down-draft cylindrical kilns, having hemispherical tops, and burned from 70 to 90 hours with bituminous coal, on grates, at intervals, around the outside base. An 80 horse-power engine suffices for this plant. The heat is sufficient to melt tin, and to cause pieces of copper to run together.

"A" and "B," of dimensions 8¼ in. by 4¼ in. by 2 in., are burned in the same kiln, but differ in color and quality. "A" is dark, almost black, rings more and appears stronger than "B,"

which is a light red. They are quoted at $8.00 per thousand free on board cars. "C" is a brick from the same clay, and made in the same way, but intended for a finished brick for face work on buildings.

At Bloomington, Ill., the "A" clay is simply tempered in a vertical pug-mill, molded into bricks by hand, dried in a yard, racked in rectangular stacks, and burned for from 96 to 120 hours with wood and bituminous coal placed in the usual arches. It is a grayish red in color, 7 in. by 3½ in. by 2¼ in., quoted at $8.50 per thousand at the yards, or furnished in sufficient numbers to lay *two* courses, one flat and the other on edge, for $1.12½ per sq. yard. Bloomington "B" and "C," quoted at the same figures, have about the same dimensions. All have a sharp, clear ring when struck.

Bricks are made at Ottawa, Ill., from fire-clay which is mined, and from common surface clay. They are burned some 50 hours with bituminous coal, in kilns similar to those used at Virden. When burned, the interior is dark gray in color, very hard, and cannot be cut with ordinary tools. They are of two dimensions, 4 in. by 5 in. by 12 in., and quoted at $1.00 per sq. yard, which is about $35 per thousand, and 4 in. by 4 in. by 12 in., at 75 cts. per sq. yard, or about $28 per thousand.

At Empire, Ohio, a light blue fire-clay is taken from a drift in the side of a mountain, ground in a pan, molded by hand, and burned in up-draft open-top kilns, with natural gas. The bricks are hard, ring like steel, and are quoted at $10 per thousand. Much the same process is employed at New Brighton, Pa., where the bricks made from fire-clay are claimed to be as hard as granite, to emit a sharp, steely ring when struck, and to resist all effects except natural wear.

In all the above cases, no addition of sand or other material is made. In Wheeling, W. Va., a brick, in form a truncated pyramid, is made from clay and iron slag.

As the condition and life of a pavement depend upon uniformity of the bricks, they should all be burnt to a uniform hardness, which cannot be obtained in ordinary kilns. If soft and salmon bricks are found at the top of the kiln, while those next the arches are over-burned, warped, and melted, the cost of the rest, suitable for use, is much enhanced by the waste.

CRUSHING STRENGTH.

All specimens were crushed by the direct application of weights. The specimens were all ¾ in. by ¾ in. by 1½ in., placed on end between pieces of soft pine about ¼ in. in thickness. The length chosen for the samples permits the shearing action to have its full effect. All were ground to true size on emery wheel and grindstone, and carefully calipered.

In Virden "A," the short axes were parallel to the 8½ in. and 4½ in. dimensions of the brick from which it was taken. It was compact, having no holes or spongy places, took on sharp corners and smooth surfaces, was excessively hard, and would glaze at a white heat on the emery wheel. With 5,266 lbs., it crushed by a scale of about ½ in. by ½ in. by 1 in., first flying off from one vertical edge, accompanied by a sharp report, immediately followed by splitting into nearly prismatic fragments, parallel to the action of the force.

A second specimen from the same brick, with short axes parallel to the 4½ in. and 2 in. dimensions of brick, crushed at 5,625 lbs.

Virden "B" did not take on as true dimensions as "A," though free from holes. Crushed at 5,160 lbs.

Virden "C," like the preceding, crushed at 4,985 lbs.

It was difficult to bring Bloomington "A," as well as the next specimen, to the required dimensions, because of a tendency to scale, when heated under the action of the emery wheel. Several holes occurred in them, as may be seen in the bricks. They also glazed somewhat under the emery wheel. Crushed at 5,693 lbs.

The second specimen crushed in smaller prismatic pieces, at 7,268 lbs.

Bloomington "B" was excessively hard to reduce to size, would also glaze, but not scale off, took on smooth surfaces and sharp edges, and had spots which contained a yellow powder. Crushed at 5,565 lbs.

Bloomington "C" was much like the above. Crushed at 5,280 lbs.

In the following table are given the specific gravity (mean of 5 determinations), the absorption for three, five, and ten days, after the specimens had been heated to a red heat, cooled in a desiccator and weighed, and finally the crushing strength per square inch of section.

Name.	Specific Gravity.	Per Cent Absorption.			Crushing Strength, lbs. on sq. inch.
		3 days.	5 days.	10 days.	
Bloomington "A"...	2.1852	3.79	3.92	4.06	12,920 max. 11,520 mean. 10,120 min.
" "B"...	2.3045	3.18	3.19	3.37	9,893
" "C"...	2.2269	1.87	2.20	2.70	9,386
Virden "A".....	2.3166	3.10	3.12	3.82	10,000 max. 9,680 mean. 9,361 min.
" "B".....	2.4150	7.67	7.96	8.71	9,173
" "C".....	2.3601	7.11	7.48	8.70	8,862
Hayden Paving Block..	2.2861	3.25	3.38	3.64	....

It may not be amiss to compare the crushing strength of the above with that of some common or building bricks.

Good Haverstraw stock bricks of a fair average, tested at East River bridge, by Mr. Abbot, with no packing between brick and machine, gave —

		Crushing strength.
Whole brick on end	max.,	3,060 lbs. on sq. in.
	min.,	1,600 " "
	average,	2,065 " "
Half brick on flat side	max.,	4,153 " "
	min.,	2,669 " "
	average,	3,371 " "
alf brick on small side	max.,	6,400 " "
	min.,	2,900 " "
	average,	4,612 " "

Experiments by Prof. W. A. Pike, Minneapolis, Minn., on building bricks. Half bricks between pieces of pasteboard.

		Failed with.
St. Louis, Mo., brick	flatwise,	6,417 lbs. on sq. in.
	edgewise,	4,080 " "
Hastings red brick	hard,	2,017 " "
	medium,	2,012 " "
	soft,	1,748 " "

BRICK PAVEMENTS.

Paving bricks are sometimes laid on a foundation of broken stone covered with cement mortar, and sometimes on sand. It will hardly be expedient to go into details now.

At St. Louis, ten years ago, strips of pavement 22 inches wide were laid down as a test, and a two wheeled cart with tires 2½ inches wide, and loaded to two tons, or 800 lbs. per inch of width, was rolled back and forth by machinery. The heaviest traffic at that time in St. Louis was 75 tons per day per foot of width, and the average for business streets was 35 tons. Estimating the effect of horses' shoes at one-third of this amount, 50 tons per foot were taken as a standard. The samples were weighed before and after testing, and were subjected to an amount of travel by the above cart equivalent to eight and one-half years on the street.

The total abrasion of the fire-brick pavement was 9 per cent., or a depth of ¾ inches, but about one-half of the bricks were broken. Asphaltum blocks under the same test wore 14 per cent., and but one was broken. Granite blocks were scarcely worn appreciably, while limestone had lost 10 per cent. The action of the elements would have affected the limestone still more, as would also probably have been the case with the bricks.

As a result, granite blocks were chosen for streets having heavy traffic. The tests seem to warrant the claim that brick pavements will answer well for moderate and light traffic.

Soft bricks intermixed may give trouble; but the first cold season will usually determine whether the bricks are hard enough,

as, if not, the moisture absorbed by them will freeze, and crumble the bricks by expansion.

At Nashville, Tenn., are used creosoted or bitumenized bricks, prepared by saturating common kiln bricks of medium hardness, under a high degree of heat, with liquid pitch, obtained by distilling coal-tar. These bricks have been laid about four years, on a good foundation of rolled macadam, bedded on edge in 1½ inches of sand, and rammed tight. They have been subjected to a considerable amount of traffic, and show very little if any wear. The cost was $1.80 per sq. yard for brick and laying on finished foundation.

At Youngstown, Ohio, fire-brick on cement concrete base and sand with pitch in joints, cost for all $1.73 per sq. yard. Their best bricks came from Empire, Ohio, and New Brighton, Pa.

At Allegheny City, Pa., fire-clay bricks from the West Virginia Fire Brick Company have been laid in two layers on rammed and rolled gravel and sand, at a cost of $1.95 per sq. yard, exclusive of grading. The pavement, in use three years, is stated to be very smooth, easily cleaned, and of a handsome appearance.

At Bloomington, Ill., some two and one-half miles of brick paved streets have been laid with bricks of home manufacture, "A," "B," and "C." The sample herewith was under traffic there twelve years. The corner and edge of one end, and also the large scale on the upper edge of the same side, were broken off with a pick in removing the specimen from the pavement. It does not appear to have lost appreciably in width, although the majority did not present so favorable an appearance, having generally lost the upper edges and corners. Such pavements, however, are not noticeably rough in driving over them, and afford good foothold for horses. The brick pavements in Bloomington, generally speaking, are in good condition, and are being constantly extended. They have stone blocks, Nicholson and macadam pavements also, and prefer brick, on the score of cost, durability, lack of noise, home production, ease of cleaning, and repairs. The entire pavement, two layers of brick, including *all materials*, grading, and stone curbs, cost $2.00 per sq. yard, with laborers at $1.60 per day, teams $3.25, and sand 80 cents to 90 cents per cubic yard, delivered.

Jacksonville, Ill., has laid over three miles of pavement with Virden brick. Some down for five years is now in good condition. One piece, of one-half mile, two layers, cost, including everything, engineer's services and all, $1.92 per sq. yard. Sand was filled into the joints in place of pitch.

Cincinnati had a pavement on rolled sand. A failure.

Peoria, Ill., paved two blocks in 1886, and five blocks in 1887, with Ottawa paving brick, and Chicago used the same brick three or four years ago on 63d St. car tracks.

The intersection of Washington and Dearborn Sts., Chicago, was paved with Hayden paving blocks in 1886. In March, 1888, it was found to have succumbed to the very heavy traffic, and crushed.

Galesburg, Decatur, Champaign, and Springfield, Ill., have laid more or less brick pavement within five years, the major part of which has given satisfaction.

New Orleans and Wheeling, W. Va., Steubenville, Ohio, Camden, N. J., and other places, have laid experimental sections.

The disadvantages of brick pavements arise from lack of uniformity in the material, and the liability of incorporating in the pavement brick of too soft and porous structure, which crumble the first winter under the action of frost.

When laid on a solid foundation, the advantages are, cheapness, smoothness, cleanliness, freedom from noise, and sanitary excellence as non-absorbent. See table above.

Taking all things into consideration, it is superior to macadam, wood, and, for a maximum traffic of three tons, superior to granite.

CHAS. E. GREENE.

President. — "Gentlemen, we must not let this paper lead us to think that we live in Ohio or Illinois. We live in Michigan. I have no criticism upon the paper as it is, but we would be glad to know: first, whether we have any Michigan clay good for this purpose; secondly, whether those clays, if we have any, have been fully experimented with, and if so, with what results? Can any gentleman give us any information in regard to that?"

Secretary. — "I think Mr. Appleton knows something about Michigan clay."

Mr. Appleton. — "It is another kind of brick we make. But I understand an experiment is now being made with slate dust, to see what the result will be, and to see if the brick produced will be well adapted to paving."

Mr. Foster. — "I know nothing of brick-making, but I wish merely to state that I made some observations in the Upper Peninsula a good many years ago, when I was engineer of the canal that passed through Lake George. We found in that lake for about 3,000 feet a mass of red clay, very refractory. There was an immense amount of it, to all appearances inexhaustible, enough to supply the entire State for ages."

Mr. Appleton. — "I have been investigating brick-making somewhat, and have found that there is a very good quality of brick made for this purpose in several different sections of the State."

Prof. Greene. — "I have also spent considerable time in looking up this matter, and I think the clay Mr. Appleton talks about does not make first-class brick, but even if it did, you can bring brick into the interior of the State of Michigan from Ohio or Illinois, at a much less cost than from within your own borders."

Mr. Appleton. — "I wish we could do away with this abominable wood pavement. North Lansing is paved with tamarack blocks. Most of our streets here were contracted at about 90 cts. per square yard, and the cobble stone with which we paved the gutters, at from 60 to 65 cents per square yard, and in some instances the cedar, has been put down for 80 cents per square yard, that including the whole business, sand and everything complete. Now this intersection of Capital and Michigan Avenues right here in front of the Capitol, as many of you well know, has been down but two or three years, while the paving on Washington Avenue has been down about eight years. That at North Lansing, where the tamarack was used, has been down about six years, and is now nearly worn out."

Prof. Greene. — "Then taking into consideration the life-time of the pavement, is not the brick pavement much cheaper?"

Mr. Appleton. — "Yes, sir, I certainly think it is."

Mr. Foster. — "When I was in the Upper Peninsula, I found several beds of fire clay only twenty-five feet from the surface, some of which I sent up to the iron furnaces, and it was pronounced first-class fire clay."

Mr. Mc Loughlin. — "I would like to inquire of Prof. Greene if he noticed any difference in the shrinkage of the raw brick and the burnt brick?"

Prof. Greene. — "You will see the shrinkage is not very much by examining these specimens. The shrinkage is very small indeed."

Mr. Appleton. — "The machine that makes this brick is of that style where there is just pressure enough to push the column of clay through the machine, and it is cut off by a wire into bricks of the proper dimensions."

Mr. Mc. Loughlin. — "I have made this subject of pavements considerable of a study, especially as we have decided in Detroit that it is necessary to substitute something for cedar blocks. I have given it about seven years of study, and there has been a great number of tests made to see if bricks could be made to stand the heavy traffic of our streets. Brick for pavement has not yet been made that is not porous, and that will not absorb considerable moisture. Mr. John Gladden has also given this question considerable study, and has spent considerable money, and even gone to the trouble of having special machinery made and an extra kiln built to burn these bricks, and paved the street from his own street to Louise St. with the brick he made. His pavement at the corner of Third and Louise Sts. has been down for about five years, and Louise St. has been paved with cedar blocks. The brick has stood fairly well there, but the traffic is light over that street. I find that in investigating this paving question, we have got to drop this idea of cheapness if we want good pavements, and if we expect to have good pavements, we must expect to put good material into

them, and the best of all is a good foundation. I think engineers will discard sand for a foundation. They will have to come down to cement, and then place stone, blocks, or whatever you wish, on top of that. I think for a cheap pavement, there is nothing like a wood pavement. If you would put under this kind of pavement, concrete instead of sand, I believe you would have a good pavement, but it would be quite expensive. At St. Louis they did some paving with locust blocks placed upon a bed of concrete, and it cost $3.65 per yard. In this method of paving, when your blocks wear out, you still have the bed left intact. You have always got a certain part of your work — the foundation — left upon which to re-pave your streets or make repairs thereafter. Therefore I think we should look at the foundation rather than what we put on top of it. But if you want a nice pavement and one that will last, you should put down a pavement of Trinidad asphalt. It is a question in my mind if it is not going to be the pavement of the future. There are objections to granite pavement in the way of noise. I witnessed in the cities of Brooklyn and New York a pavement that had been down for fifteen years. It was made of granite blocks of 3½ inches by 6 to 9 inches long and 7 inches deep; that pavement had been laid on broken stone which had been well rolled with a heavy roller, and then on top of that the paving stone which had also been rolled; but in that fifteen years of traffic over it, it had become very uneven, and at the time I was there they were then ending up the blocks, when it would be good for another fifteen years. It cost in the neighborhood of $4.50 per yard, or between $4.50 and $5.00.

"In Washington, where they have finely paved streets, and where they have had the Nicholson pavement, they have discarded it, and have adopted the standard pavement of asphalt. In Buffalo, Medina stone pavement has been preferred to other systems, and that put down there is now on its seventh year; Rochester has quite a large amount of it; St. Paul and several other cities which I might mention, have adopted this Trinidad asphalt pavement after a great deal of inquiry and investigation. The city of Detroit is now agitating this question, after having tested brick, wood, and various other kinds of pavement. We have a place on Michigan Avenue where we tried the brick pavement, but it was not found to give satisfaction. In the choice of pavements, you have got finally to get down to these two facts: You want solidity and elasticity, and these are the elements embraced in the Trinidad asphalt pavement. In the old world the people are still sticking to the stone pavements of one kind and another. Paris uses asphalt almost altogether, although right here I wish to state, what probably most of you know, that there are several grades of asphalt. The Neuchatel asphalt becomes very slippery with wear, but Trinidad asphalt does not. They are using fine sand, and mix with it as much

of the Trinidad asphalt as it will stand, but there is such a thing as taking too much sand In Columbus, this brick pavement is a failure. They pave with vitrified brick, and in slippery weather horses cannot stand on the pavement. They are now going to use asphalt instead. The brick of the best quality costs $1.92 per yard, and the cost of the foundation is still to be included. With the best brick you have, your pavement will cost $3.00 per yard, and I doubt very much whether that would be economy. The $1.65 brick would bring the cost up to $2.00 per yard. I would much rather have the road bed well filled with bank gravel, and well rolled, and then laid with 7-inch cedar blocks, well filled between with gravel. Then sprinkle the streets thoroughly, and they will last much longer than when not sprinkled, as the dry rot will not set in, and for the amount of money you will have a much better pavement than you would have with brick. If you will keep your streets well watered, the life of the pavement will be longer than when left subject to the weather. Any city that wants a *good* pavement should not put down any pavement excepting the asphalt."

Mr. Ames. — "The pavements of Grand Rapids are altogether cedar pavements. It perhaps might be advisable in some localities to use boards under the pavement for a foundation, but in Grand Rapids our soil is well drained, and it is not necessary. We have taken up and replaced pavement where all that we needed to do was to take up the blocks and put them down again, our soil being such that there is no danger of the blocks settling into it. While a city is growing, and the pavements are constantly being torn up for the purpose of putting down gas and water pipes, and putting in drains and sewers, it would hardly be advisable to put down any very expensive pavement; but it might be well for a city which has its growth to do it, along certain streets. Twelve years is the longest we have used pavement."

Mr. Mc Loughlin. — "I don't care what pavement is taken up, if you will hire competent workmen to do the work and not allow the ditcher to set back the blocks or stone, it can be put back in just as good shape as it was originally. But if you make your repairs properly, it will cost a good deal of money."

Mr. Granville. — "In Saginaw, toward the latter part of each summer the streets that are to be opened the ensuing year, are ordered, and upon such streets' being paved, the Board of Public Works, or its officers, order all connections to be made, though the city authorities have no means of compelling the putting in of anything but the sewer connections. They have the power after the pavement is once put down to compel the payment of $25 by the property owner who wishes to make any connection before entering the pavement, and then if they cut into the pavement over five feet, it is $1.00 for each additional foot. As a consequence, nearly all the connections are made before the paving is done. Now suppos-

ing at some future time a person wants to make connection, he makes his application, and agrees to pay all the damages of taking up and replacing the pavement; the street superintendent, or men under his control, make all the connections; the contractor or plumber makes the trench and puts in the pipes, when his work ceases, and the work of replacing the pavement is left in charge of the superintendent of streets; and the applicant pays into the city treasury the cost of the work."

Mr. Ames. — "In Grand Rapids, the city engineer has nothing to do with the streets. After the streets are opened, it is then in the hands of the Board, and the city engineer has nothing to do with it. The city has no ordinance compelling the people to make connections before the pavement is put down, and the result is that our streets are continually torn up."

Mr. Mc Leod. — "At Manistee we adopted another system this year, differing somewhat from the one formerly adopted. At the time of putting in our sewers, we put in our lateral sewers. But we have nothing to do with regard to the water and gas pipes. I would like to ask the gentleman from Detroit, what kind of timber or lumber you use under the pavement?"

Mr. Mc Loughlin. — "That would depend a good deal upon the lay of the ground, and kind of soil; where you have a fair sub-soil of clay, a good board is sufficient; where you have boggy soil, a 2-inch plank."

Col. Muenscher. — "If you have a good natural foundation, I think the board foundation is entirely unnecessary. I agree with Mr. McLoughlin in regard to pavements, to a great extent. In the large cities it is all right to put down permanent foundations where the property is worth $500 to $600 per foot frontage, but in the smaller cities where it is worth but $50 to $60 per foot frontage, we have got to have something cheaper, as the paving would cost more than the property is worth. I am in hopes to see brick take the place of wood for pavements."

Mr. Mc Loughlin. — "We had occasion to take up some block pavement that had been down for some years, and we failed to find a rotten block in the whole, although it had been down so long that the blocks which were originally seven and a half inches high, had in many places become worn down to two and a half inches. They have in all Canadian cities a system of pavement with blocks, and their streets are sprinkled thoroughly every day, and any wood that is put down in that way is a good pavement, and much cheaper than brick. Chicago has adopted granite for its pavements, but the noise and the rumbling and roar of their wagons passing over them, make it very disagreeable, especially for residence streets."

Mr. Watkins. — "Here they all adopt a block that is seven or eight inches in length. Why not have a block only three or four inches, as it will be less liable to tip?"

Mr. Mc Loughlin. — "We find from experience that a seven-inch block is the best to use."

Mr. Watkins. — "In New York City, where I have seen all those various pavements go to the wall after a little while, the Rust pavement seems to be the best one for the larger cities. For small cities I think a short cedar block pavement is the best thing we can get."

Mr. Goodale. — "We have a small place of about 1,000 inhabitants, yet we need good streets, and we think we can afford good pavements. We have put down stone gutters with gravel and clay between. I would like to know what the comparative utility and cost of the stone pavement is as compared with cedar blocks."

Mr. Appleton. — "Cedar block pavement, with its excavation, costs from 80 to 90 cents per square yard."

Mr. Mc Loughlin. — "How large a block do you use?"

Mr. Appleton. — "We use anything from three to eight inches in diameter."

Mr. Watkins. — "Do you use boards for a foundation?"

Mr. Appleton. — "No, sir, we don't need any here."

Prof. Greene. — "I know of some brick pavements in which the entire cost, including all necessary preparations and engineers' surveys, was only about $2.00 for a good pavement. I understand that the clay found in Southern Michigan is not good for brick for paving purposes."

Mr. Appleton. — "I want to ask the gentleman from Detroit, who just spoke, if he does not find it a rather difficult matter to get good *pavers?* You can find plenty of men who can lay the stone, but you cannot find very many men who can lay it properly. There are all sorts of schemes to get down a good deal of the pavement, but I always found it difficult to get just the right kind of pavers."

Mr. Mc Loughlin. — "There are lots of them; but if you want a good stone pavement, you don't want to go to Detroit to get your good pavers. I can teach any sensible man in two or three hours' time, to lay a pavement, and lay it well. The stone should be laid dry, and rammed down with a rammer that will cover only one stone at a time. Of course it takes considerable time to teach a man so that he can lay to the crown of the street nicely. But no man can pave for me, and lay his 125 or 150 yards per day. If he lays 75 yards, he is doing a big day's work."

Mr. Watkins. — "How should stone pavements be laid?"

Mr. Mc Loughlin. — "The large end up."

Mr. Watkins. — "What is to prevent a person from kicking them right up?"

Mr. Mc Loughlin. — "They should be laid dry, as I said, and then rammed down well. The sand should then be broomed over them, and they should be rammed again, and the sand again

broomed over them, and again pounded down, and so on for three times. I have seen them put down where they could not be taken out with a pick."

NOTES ON BUILDING STONES.

MICHIGAN is surpassed by many other States as a producer of building material. Quarrying is not one of her most important industries. Recognizing these facts, the writer of the brief paper here presented, wishes to offer a few notes on building stones in general, and to call attention to the meagerness of the published information relating to Michigan stone, with the hope and expectation that, for some future meeting of this Society, a more extended and systematic paper may be prepared that shall show in fuller detail what kinds of stone are obtainable within the boundaries of the State, and to what extent it may reasonably be expected that the quarry industry can be developed. The writer wishes to say further that he has had but little opportunity personally to visit the quarries alluded to in what follows, and that he has relied principally for his information about them upon the following publications: (1.) The "Report of the United States Census for 1880;" (2.) The five volumes of "Mineral Resources of the United States," issued by the U. S. Geological Survey from 1882 to 1887; (3.) The reports of the Michigan Commissioner of Mineral Statistics for the years 1878–87; (4.) The several reports of the State Geological Survey. Outside of these publications, there seems to be little or nothing of value in accessible form that relates especially to Michigan quarries.

The United States Census of 1880 made record of such quarries only as did a business in the census year amounting to one thousand dollars or more. Of such quarries there were in the whole country, in 1880, 1,525, employing a capital of $25,414,497, and producing 115,380,133 cubic feet of stone, valued at $18,356,055. Michigan's share in these totals was nine quarries, with an invested capital of $74,700, and a production of 648,060 cubic feet, valued at $79,165.

The nine Michigan quarries of which statistics are given in the census volume, are the limestone quarries at Alpena, at Sibley's Station in Wayne County, and near Raisinville and Dundee in Monroe County, and the sandstone quarries at Lulu, Monroe County, at Stony Point, Jackson County, at Ionia, and at Marquette. No reference is made to the sandstone of L'Anse, though considerable work had been done at that locality as early as the year 1875, nor to the slate of Huron Bay. Besides the places just mentioned, the Michigan reports speak of several other localities where limestone or sandstone, that have either been proved to be,

or are supposed to be, of value for building purposes, have been worked to some extent, or are at least exposed to view in promising outcrops. Among these may be enumerated, though the list is doubtless incomplete, Springport, Sandstone, Parma, and Napoleon, in Jackson County; Flushing, in Genesee County; Trenton, in Monroe County; Bay Port, in Huron County; and numerous points of minor importance in Barry, Eaton, Hillsdale, Iosco, Kent, Saginaw, and Shiawassee counties.

In what has preceded, no allusion has been made to stone other than limestone, sandstone, and slate; and, indeed, there is no reason for expecting to find good building material of the crystalline or granitic character in the State of Michigan, except in the western portions of the Upper Peninsula, or among the boulders distributed through the glacial drift that almost entirely covers and conceals from view the sedimentary rocks of the whole lower Peninsula.

In regard to these rock-names and others in use, it may be well to say a word in passing before speaking more particularly of the quality and value of stone from individual quarries. Rock nomenclature is not in the most satisfactory condition. The popular names, *sandstone*, *limestone*, *slate* and *granite*, are made to cover almost every variety of stone in at all common use, except where occasionally some more specific term finds application; as, for example, *bluestone*, suggested by a characteristic color; or *flagstone*, named from the use to which the stone is to be put; or *Ionia stone*, so called from the locality where quarried. The term *slate* is a convenient one to apply to any rock that readily cleaves into thin plates with surfaces approximately parallel, and *sandstone* is a term generally applicable to rocks made up essentially of rounded grains of quartz, or other hard mineral held together by a cementing material of some kind or other, though it must not be supposed that all slates are alike, or that all sandstones have the same properties; but *limestone* includes not only the common, coarse varieties, but also the finer grained and more highly prized marbles and the so-called dolomites, or magnesian limestones. The name *granite* is perhaps the most abused of all. True granite is a mixture of quartz, feldspar, and mica, in which the different mineral ingredients are crystallized together, and are large enough to be recognized by the unassisted eye; but some rocks, locally known as granite, are nearly or quite barren of quartz, feldspar, or mica, and resemble true granite only in their crystalline granular texture. The traps, porphyries, greenstones, basalts, serpentines, etc., need no further mention at this time, for the reason that they occur in Michigan only in limited amount, or, at any rate, with only a very limited use for structural purposes. In the vicinity of Ishpeming, in the Upper Peninsula, marbles and serpentines do, indeed, occur, that take a good polish, and furnish pretty hand specimens, but, so far as known to the writer, they

are not obtainable in large, homogeneous blocks such as would be required for building purposes.

In determining whether any rock, by whatever name it may be known, is likely to prove serviceable as a building material, especial attention must be directed to its texture, that is, to the way the individual mineral ingredients of which it is composed are held together. In respect to texture, two great classes of rocks are recognized; viz., the crystalline and the fragmental. In the former, the mineral grains are held together by the mutual adhesion of crystalline surfaces, while in the latter, the rounded or the angular fragments, that once existed in other relations as parts of other rocks, are held or stuck together by the intervention of some foreign substance that acts as a mortar or cement. It hardly needs to be mentioned that the strength, durability, and value of a fragmental rock depend fully as much on the character of the cement, which may make up only a small portion of the total volume, as they do on the rock fragments that compose the mass of the rock. Crystalline rocks occur in greatest abundance in regions where eruptions of molten matter have taken place, or where sedimentary formations of great geological antiquity have been metamorphosed through the agency of moisture, pressure, and heat. It is for this reason that in Michigan the crystalline rocks are limited to the districts mentioned above, and that throughout the Lower Peninsula, where the geological formations underlying the drift range from the Upper Silurian to the Carboniferous, rocks of a fragmental, sedimentary character are the only ones to be expected, unless possibly a few of the limestones may exhibit to some extent a crystalline or subcrystalline character.

The well-known quarries of red, or reddish brown, sandstone at and near Marquette, are referred by geologists to the Potsdam period at the base of the Silurian system. The mottled appearance of some of this stone is due to the unequal oxidation of the iron that is present. The rocks of the other geological formations of the eastern portion of the Upper Peninsula appear to be too thinly bedded, too friable, or too much cut up by cracks and seams, for the production of blocks of desirable shape and size. The sandstones of the more southern counties of the Lower Peninsula are mostly subcarboniferous in age; the Ionia quarries are in the coal measures.

To be of value as a building material, a stone must possess sufficient strength, must be capable of resisting climatic and meteorological changes, must present a pleasing appearance, and must be obtainable in large quantity at low cost. These desirable properties are not dependent entirely, nor even to any large extent, on the mineral constituents of which ordinary rocks are essentially composed, for these minerals are all of the most common varieties; but rather on closeness and compactness of texture, on density and degree of consolidation, the character of the cementing material,

if any, and freedom from accessory ingredients, that, though small in quantity, frequently cause discoloration or disintegration and decay of the rock mass, in consequence of slow chemical changes that take place in them when exposed to the action of air and moisture.

So far as ability to resist crushing is concerned, it is safe to assert that in all ordinary structures, there is little or no danger of a rock's breaking or cracking under the load it has to carry, if only ordinary care is exercised in its selection. About fifteen years ago a report of experiments upon various American building stones was prepared by General Q. A. Gillmore, of the United States Army, and from this report it appears that of seventy-eight granites tested, the crushing strength in pounds to the square inch ranged from a minimum of 7,750 to a maximum of 22,750; for forty-seven limestones and marbles the minimum and maximum were 6,650 and 25,000; and for fifty-eight sandstones, 4,025 and 17,725. These figures do not agree exactly with those given by other experimenters, but they may be accepted as an approximation to the truth, and they certainly show that the stones in the lower courses of masonry are still abundantly able to sustain the weight of the superstructure in the highest building or column yet erected. There is still room for extensive study of questions relating to the causes of fractures along certain planes, and the development of weakness in certain directions under varying circumstances.

Among the several conditions that affect the durability of rocks, their porosity is one of the most important. Notwithstanding the apparent solidity and closeness of grain of the stones seen in daily use, it can be easily shown that many of them are porous in no slight degree. The pores and openings are indeed small, but their existence is made manifest in several ways, notably by the absorption of water. To show the extent to which different varieties of rock are capable of absorbing water, the following data are taken from Dr. T. Sterry Hunt's "Chemical and Geological Essays." The numbers represent the volumes of water absorbed in each case by one hundred volumes of rock. For fourteen kinds of sandstone experimented upon, the volumes of water absorbed ranged between 1.39 and 21.27; for five shales, between 0.75 and 7.94; for five limestones, between 0.30 and 1.70; and for twelve dolomites, between 2.15 and 13.55. In the most porous rock the absorption amounted to more than one-fifth its original volume.

Where any high degree of porosity exists, it is evident that this circumstance alone will facilitate the decay of a rock by introducing into its interior the agents of chemical change that are to be found in all atmospheric waters. What these chemical agents are, and how they act in association with mechanical and organic causes of destruction, would be an interesting subject for discussion, but such a discussion does not fall within the scope and purpose of the present paper.

PROF. W. H. PETTEE.

President. — "I feel rather humiliated that I should have to live in a State so long, that has in it no building stone fit for building purposes. I knew, of course, that when we wanted to build large buildings, like the State Capitol, we have to send outside of the State for building stone, but it seems to me we should have abundant material of that kind for smaller buildings."

Mr. Foster. — "We are not entirely destitute of good building stone in this State. At Portage Entry, near the light-house, there is a much larger quarry, and it is better equipped, than many in other States from whence we procure our stone. The stone is sent from there by means of scows to Marquette for building purposes, and they are using it to a considerable extent. The new Mining School at Marquette is being constructed out of it. It has the advantage of being located at a point that is very accessible, with a roadstead for a good harbor. Then on Isle Royal, I believe, on Siskowit Bay, there are cliffs, miles in extent, of stone that is of fine quality for flagging and paving stone, and this is also provided with a good harbor, being situated on the extreme south side of the island. No quarries have been worked there, although people from Chicago have looked at them, but have opened no quarries yet."

Mr. Watkins. — "What about Grindstone City stone?"

Mr. Pettee. — "That stone is used especially for grindstones, and I am not aware that it is quarried for building purposes."

Mr. Rothwell. — "I would also add that in the years from 1876–80 there were over 27,000 cubic yards of stone taken from Limestone City for use at the 'Soo?'"

President. — "Are there any other kinds of stone used in building at the 'Soo?'"

Mr. Ripley. — "Sandstone is used to a considerable extent, in fact, almost entirely for foundations to buildings, and there are one or two churches built with it."

Mr. Rothwell. — "There is some good building stone to be found in the quarries at Big Bay De Noquet and on the eastern side of Green Bay, although they have been worked but little."

Prof. Carpenter. — "There has been considerable of the Ionia and Grand Ledge stone used in this city for building purposes. It has been found to stand well. The Grand Ledge is of very poor color, but is found to be quite durable, and would be quite desirable stone for building purposes were it not for the dirty streaks running through it."

Mr. Ames. — "The stone procured from the sandstone quarries at Holland is of a light gray color, and when first quarried is quite soft, but grows harder upon being exposed to the air for a time. I have never noticed any discoloration from iron."

TIME AZIMUTHS.

It may not have occurred to many of our surveyors that in the recent establishment of Standard Time, we have a new means of finding meridian, — not new in a literal sense, for it is well known to navigators, — but new in that it has not been utilized by land surveyors.

We already avail ourselves of the properties of the "astronomical triangle," so called, for the purpose of finding meridian with the solar campass, or transit.

In this we determine the zenith angle of the triangle, and thence the supplement, mechanically, from the three sides, — a case of spherical Trigonometry.

But in the method I propose to bring to your notice, we have in the same triangle the two sides meeting at the pole, and their contained angle, which we may assume at pleasure, from which to find the zenith angle.

The two sides we have from the same source as when working with the solar transit.

The third element. — the angle at the pole, — called also the time or hour angle, is now known from the standard time established, and the *equation of time* as given in the nautical almanac.

From standard, which is mean time, and the equation of time, *apparent time* is readily deduced, which at 15° per hour gives hour angle for any instant between the meridian of the observer and that of the sun, or star, as seen from the pole.

The question is to deduce from these data the bearing of the sun, as seen from the observer.

This will require a knowledge of our latitude and of the sun's declination approximately, and of our *local apparent time precisely*. Though the azimuth is a function of the three elements, it depends most immediately on the time angle.

If we know the latitude to a few minutes, or one-fourth of a degree, it is quite sufficient. The sun's declination is given precisely in the nautical almanac, but if we have it for the second or third year after leap-year, it is sufficiently precise for any of the four years, for ordinary work.

The importance of precision in the apparent time, is seen by consulting the tables of time azimuths, in use by navigators.

By these it will be seen that when the sun is near the meridian, the rate of change of azimuth is much more rapid than when farther away. Thus, in our own latitude of say 42°, with declination 20° N., the sun changes azimuth 10° in the first 15 minutes of time from the meridian, or 40′ of azimuth per 1 minute of time.

At 2 hours from the meridian, the rate is reduced to 20′ of azimuth per 1 minute of time.

Also, the rate of change is reduced by increase of distance from the Prime Vertical. Thus for lat. 42° N. with declination 20° S., and for time angle 4 hours or 60°, the rate of changes is only about 10′ per 1 minute of time, whence, *the best results are found with the sun as far from both meridian and Prime Vertical, as practicable.*

The problem of finding longitude is not difficult, now that the whole country is surveyed, and land-marks established. Every light-house around the entire chain of lakes and rivers, and coast of the country, is an *illuminated land-mark*, whose co-ordinates of place are given, and recorded, to the nearest second of arc, and are furnished for the asking to all owners and masters of American ships.

In the interior of the country, every observatory is a point whose co-ordinates of place are known; and the topographical surveys of the country have determined the location of many other places.

The Government surveys afford the means of counting distances, so that from them the difference of latitude and the difference of longitude can be computed, by knowing the lineal value of these elements for the locality. Then the application of the equation of time gives us *local apparent time.*

I give herewith a table showing the length of one minute of longitude, in statute miles, at every one-half degree of latitude, from 30° to 60°, from which distance east or west, or departure, as we may call it, may be readily reduced to minutes of longitude, nearly anywhere in the United States.

I also give a list of places with their co-ordinates, as taken partly from the "Government List of Lights," partly from "Prof. Winchell's History of Michigan," and partly from "Henck's Pocket-Book." From these, and the Standard Time, which may be readily known to the fraction of a minute, it will not be difficult to find the local apparent time to a good degree of precision.

This being known, the following equation will give us the azimuth corresponding to any assumed time angle, for any latitude and declination.

$$\text{Tan } Z = \frac{\sin H. \cos D}{\cos H. \cos D. \sin L \mp \sin D. \cos L}$$

In which Z = azimuth desired, H = time angle, D = declination, and L = latitude.

The above equation solves the case of spherical trigonometry, —*given two sides and their included angle to find the other parts*— but by a process very different from that given in our text books.

A reference to the accompanying diagram, with a little discussion, will show how the equation was derived, and show the office of each part.

I have written on the several lines their names, so that little further explanation will be needed.

It will be observed that the upper half of the figure represents the plane of the *meridian*, while the lower half represents the plane of the *horizon*, the two planes being at right angles to each other along the lines "North" and "South."

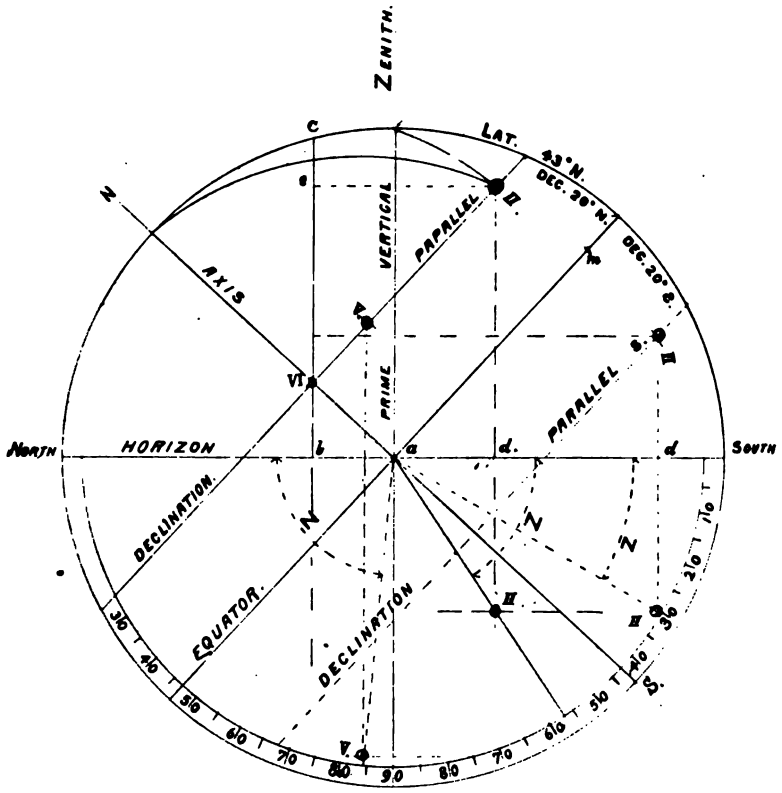

DIAGRAM.

CONSTRUCTION OF THE EQUATION.

The problem is to locate the projection of the sun, or other object, on the plane of the horizon, for any instant of time, whence its bearing is found.

The example projected is for L = 43° N., D = 20° N., and H = 2h. or 30°. Required Z.

It will be observed that the sun, bating the effect of change of declination, travels in a small circle, whose radius is the cosine of D. Also that the projection of the sun on the plane of the me-

ridian for any H or time angle, is the cosine of H on that radius, whence *cos H. cos D.* represents the distance of the sun from the earth's axis, measured along the cos D. (See Diagram.) So that at H = 30°, the sun is seen on the plane of the meridian, at II.

Multiplying cos H. cos D. by sin L, we have *cos H. cos D. cos L* = distance E II., which is the distance of the sun from a plane perpendicular to the plane of the horizon, parallel to the plane of the Prime Vertical, and passing through the center of motion at VI. Thus we have the first part of the denominator.

But we wish to refer the place of the sun to the plane of the Prime Vertical. By looking at the figure, we see that this distance for north declination is too great by the distance *ab* = sin D. cos L., though for South D the distance *ab* must be added. Whence the distance of the sun from the plane of the Prime Vertical, as sun projected on the plane of the horizon, at *a* = cos H. cos D. sin L = sin D. cos L.

The distance of the sun from the plane of the meridian, is the sine of H in terms of the radius of the declination parallel, or as sun from *d* = d II. = sin H. cos D.

Thus, from a well-known property of the plane right triangle, we have, for angle *ad* II. = Z,

$$\text{Tan Z} = \frac{\text{sin H. cos D}}{\text{cos H. cos D. sin L} \mp \text{sin D. cos L}}$$

which is the desired equation.

With L and D of the same name, the declination parallel in which the sun moves will always cross the Prime Vertical *in less than six hours* from meridian. Thus, in our example, it crosses that plane before 5 P. M. or 8 A. M., and the projection of V is seen at V′ on the north of the Prime Vertical, and the angle Z is measured from the north, as shown.

I have shown the place of the sun for S declination, and II = 2 h. at II′ and II‴.

I think the student will have no trouble in apprehending the full idea of this problem from the preceding explanation, which may be open to the objection of being more diffuse and elementary than good taste would warrant. But as this is a new solution of the problem, I wished to be sure of being understood.

The one objection to this method, is the necessity of great precision in the finding of the *local apparent time*, and the consequent error of the watch. But the advantages are many.

We require no expensive instruments, as "*Solar Attachment*" for transit, and no sextant. We have to make no observations for latitude, as we can find that element near enough, from maps; no corrections for refraction, or semi-diameter.

The surveyor should make his computations beforehand, and note the time by his watch, when the sun is at any given distance from the meridian, with the corresponding azimuth.

He should set his Z angle off to the *left* of the zero of his instrument plate in the forenoon, and to the *right* in the afternoon; then, a few minutes before the time for an observation, direct his telescope to the sun, and keep it there by means of the motion on the spindle, the plates having been clamped. At the time the watch indicates the given time for which the azimuth was computed, clamp the spindle motion, and turn the plate vernier back to read " O," *when the telescope will be in the meridian.*

A little practice will make the observer expert in this matter.

Following is the numerical work of the above example, which we have treated graphically: —

L = 43° N.	Cos. (H = 30°)	Log. 9.93753	To find Z	
D = 20° N.	Cos. (D = 20)	" 9.97298	Sin. (H = 30°) =	9.69897
H = 2h = 30°	Sin. (L = 43)	" 9.83378	Cos. (D = 20) =	9.97298
Corresponding number = .5550		= — 1.74429		— 1.67195
			.3049 "	— 1.48416
	Sin. (D = 20°)	" 9.53405	Tan. Z.	= 10.18779
	Cos. (L = 43)	" 9.86423		
Corresponding number = .2501		= — 1.39828	Whence	
Divisor = .3049			Z = 57° 1′	

LATITUDE AND LONGITUDE OF A FEW PLACES IN MICHIGAN AND VICINITY.

Place.	Point of observation.	Latitude N.	Longitude W.
Lake Survey.			
Little Traverse	Light.	45° 25′ 07″	84° 58′ 05″
Charlevoix	"	45 19 15	85 15 21
Manistee	Pier Head Light.	44 15 00	86 20 37
Muskegon	"	43 13 39	86 20 08
Grand Haven	"	43 03 30	86 20 30
St. Joseph	"	42 06 47	86 29 19
Michigan City	"	41 23 21	86 54 22
Chicago	"	41 43 21	87 36 35
Milwaukee	"	43 01 36	87 53 51
Escanaba	"	45 44 40	87 02 30
Marquette	"	46 32 48	87 22 35
Duluth	"	46 46 49	92 05 11
Prof. Winchell.			
Detroit	St. Paul's Church.	42 19 46	83 02 23
Saginaw	Light-house.	43 38 38	83 50 54
Ann Arbor	Observatory.	42 16 48¼	83 43 43
Niles	Trinity Church.	41 49 46	86 15 37
Traverse City	Pier Head.	44 46 00	85 36 53

VALUE IN STATUTE MILES OF ONE MINUTE OF LONGITUDE FOR EACH HALF DEGREE OF LATITUDE, FROM 30° TO 60°.

Latitude.	Miles.	Latitude.	Miles.	Latitude.	Miles.
30°	.9991	40°	.8842	50°	.7422
½	.9940	½	.8778	½	.7345
31	.9889	41	.8712	51	.7268
½	.9837	½	.8646	½	.7190
32	.9784	42	.8579	52	.7111
½	.9731	½	.8512	½	.7032
33	.9676	43	.8443	53	.6952
½	.9622	½	.8375	½	.6872
34	.9566	44	.8305	54	.6790
½	.9509	½	.8235	½	.6708
35	.9452	45	.8164	55	.6626
½	.9394	½	.8093	½	.6544
36	.9336	46	.8021	56	.6460
½	.9277	½	.7949	½	.6377
37	.9217	47	.7875	57	.6293
½	.9157	½	.7802	½	.6208
38	.9095	48	.7727	58	.6123
½	.9033	½	.7652	½	.6048
39	.8970	49	.7576	59	.5551
½	.8907	½	.7500	½	.5865
				60	.5778

H. C. Pearson.

President. — "The paper of Mr. Pearson will appear much better to us all when we have it in proper form. When we get it into our report with the tables that are here given, the paper will appear much more useful than it does here."

PINE LAND SURVEYING.

Mr. President and Gentlemen: —

Last summer while at work on the head-waters of the Thunder Bay and the Cheboygan River, a letter from our Secretary was forwarded to me from my home in Saginaw, requesting me to write a sketch of my daily life in the pine woods. The manuscript (with the exception of the date of the completion of the survey) was written during my leisure moments while sitting, "tailor fashion," on my bed in my tent, with a box of stationery by my side.

Before the United States Government disposed of the land in Michigan, surveyors were sent who divided it into sections one mile square, containing 640 acres each. They marked trees on

the lines each way, thus surrounding each section with a line of "blazed" trees, then sold it in tracts of one or more "forties" (that is, forty-acre lots, being one-fourth of a mile square), as the purchaser desired. If he buys less than a whole section, or sixteen forties, he must get the interior lines marked at his own expense.

When a lumber firm wishes to cut the timber on their land, they usually send men to cut out the "tote road," or road on which to draw supplies from the nearest road already built, and build the camps, then send for a surveyor to mark the lines around the land to cut by.

Years ago some firms made a practice of having the camp foreman or some "land-looker" (a man who makes a profession of examining wild land to estimate its value) run the lines with a small hand compass, and sometimes measure the distance with a pole or tape; but more commonly by "pacing," stepping off the number of steps that experience teaches him will make the required distance. Different men take different numbers to make the same distance, as some take longer steps than others; but in the last few years, "stumpage" (the value of standing timber) is so much more valuable that owners of adjoining land are watching so closely that it does not pay to take the risk of having to pay for timber cut on the land of other parties.

When the foreman sends to the office of the company, that he is ready for the surveyor, that he "must have him at once, cannot wait," as is usually the case in Saginaw, if the same call comes from a dozen or more camps at about the same time, the surveyor is at his wits' end to know how to do all the work. He surely cannot do it all at once, and he does not want to refuse any; so he makes all sorts of promises, to put off those he cannot accommodate first, usually promising to go from one camp to another nearest to where he does his first work. He takes his compass and chain, and goes to the nearest point reached by public conveyance, and if he is so fortunate as to meet the "tote team" from the camp, he will ride to camp on a load of supplies, or, as is frequently the case, if the road is so rough that it is harder work to ride than to walk, he puts his tools on the load and walks behind, usually getting into camp at night. He makes himself known (if he is a stranger) to the foreman, and asks for help for the next day.

The camps are now usually built so as to have one building exclusively for cooking and eating, with a bed in one corner for the cook and "chore-boy," (it makes no difference what his age is, he is "chore-boy" all the same), and one building for the men to sleep in, with "bunks" on each side and sometimes across one end. They are wide enough for two, and are usually one above another. Stationary seats are made in front of them, level with the lower bunks. At the end of each bunk, is a post of round timber which reaches above the upper bunk, with a one and-a-half or two-inch hole bored through at the bottom of each bunk, into

which is fitted one end of a round stick, the other being in a like hole bored in the log of the side of the camp.. On these the boards are laid which form the bottom of the bunks, with a narrow board set on edge in front and another cut and fitted from this to the log, to form the division between the bunks. The bed consists of a tick filled sometimes with straw, but more often with hay, over which a blanket is spread, and usually two pairs of blankets for a covering, each man furnishing his own pillow, usually the clothing he wears through the day. Sometimes his "turkey," a common grain bag containing his extra clothing, serves for a pillow. Sometimes the bed tick is omitted, and the hay put into the bunk loose.

Towards the door (which is in one end) from the center of the camp, is a large box stove, on which usually stands a galvanized iron kettle filled with half a barrel of water kept hot for washing, and mixing horse feed. The pipe runs up high enough to be out of the way, then turns and runs back of the center, where it again turns and runs out one side of the center of the roof, as there is a large log in the center on which one end of the roof-boards rest, the other end resting on the top log of the side of the camp, and supported in the middle by another large log, running lengthwise of the camp. From one to the other of these, under the stove-pipe, are a number of wires taken from baled hay, on which wet clothing is hung in the evening to dry. The roof-boards are covered with tarred paper instead of shingles, thus making it nearly air tight, and retaining the steam from wet and soiled clothing, the breath of the whole crew, etc. A person entering the room in the night would, with the first breath he inhales, be tempted to retreat.

Next the door, one bunk is left out, as a place to pile wood on one side and for a wash-room on the other. A long sink is made, extending from the door to the corner, with the corner end the lowest, and a spout through the logs to a ditch on the outside. A pork-barrel is set in the corner and filled with water, into which the wash-dishes are dipped for washing; and by the time forty or fifty men wash, and wipe on the two or three towels which are furnished, they are not very dry or clean; consequently it is advisable to carry a small towel in your pocket for your own use.

In most camps there is a small building for an office, in which is kept a stock of clothing, tobacco, and other things that may be needed, to sell to the men during the winter. These are kept on shelves at one side, near the door, in front of which is a counter. In the back end are beds for the foreman, clerk (if they have one), scaler, and visitors. Here the surveyor usually sleeps; if not, he must sleep with the men in the other camp, and take the consequences, which are not always pleasant, as the blankets sometimes contain undesirable bed-fellows.

About five o'clock in the morning, the chore-boy blows a tin horn, which is from four to six feet long, and can be heard for

miles. This is an invitation to get ready for breakfast, and gives the men time to dress and wash, when a single blast of the horn announces breakfast ready, on the table, and getting cold; and he who wants it warm must get there to eat it.

No talking is allowed in the "cook-camp" at meal time. Each man has his particular seat, rushes to it, helps himself to whatever he wants, if he can reach it, if not, asks his neighbor in a suppressed tone to help him, eats as though a fortune depended on his finishing the meal in so many minutes, and is on his way to the door before he swallows his last mouthful.

This is a description of camps as they are now built, where saw-mills are convenient to secure lumber, and transportation facilities are ample to carry in stoves, etc.; but years ago the camp was covered with "shakes," thin pieces of pine split from a log about three feet long, and laid from one pole to another, which usually (but not always) kept out the rain. But "shakes" offered no resistance to the wind, or the drifting snow. There was also a "caboose" in the center, made of logs ten or twelve feet long, forming a square, notched into each other at the ends so as to be level with each other. This was filled with sand, on which the fire was built, frequently made of half a cord of hard green wood. There was a hole in the roof for the smoke to escape. When the fire burnt down, it left a large mass of bright coals, over which the food was cooked, the cooking and sleeping being done in the same room. The bread and beans were baked in the "bean-hole," a hole dug in the corner of the caboose, with some live coals and hot ashes and sand put in the bottom. The bread or beans were put into an iron pot with a tight cover, which was set in, then covered with hot coals and ashes, and left until properly cooked; in the case of beans, all night. At that time the men were less liable to sickness than now, as they were sure of plenty of fresh air, the only adulteration being smoke and ashes, which were frequently more plenty than pleasant.

The foreman will detail as many men as the surveyor wants, usually one axman and two chainmen, from those he can best spare. If he has any that are good for nothing else, he will send them, as all the best men have work that must go on. He usually goes with the surveyor to some corner on the Government survey, then leaves him to find the rest himself. Where the brush is not too thick, the surveyor goes ahead, keeping one eye on his line, and the other on the chainmen, followed by the axman, who is ready to cut the way through any obstruction too thick to pass without, the chainmen bringing up the rear. The first time through on a line as few marks as possible are made, setting temporary "tally-stakes" at the end of each five or ten chains, according to whether he uses a half chain or a chain (thirty-three or sixty-six feet); and when he gets through to the next Government corner (he should seldom, if ever, assume a corner set by some

other surveyor to be correct), one-half mile or one mile as the case may be, note in his field book the entire distance between the two corners according to his chain as well as the links, to right or left, and the bearing of the random line according to his compass; then correct his bearing and run back, setting the tally-stakes over, *pro rata*, and marking the trees between, thus leaving nothing behind on the random line which might mislead the choppers, while cutting the timber. If a corner is to be set between the two corners measured from, set a temporary post at the proper distance on the random line, and then set it ahead or back, as well as to right or left, *pro rata*, as the section over-runs or falls short. Thus it makes no difference whether his chain is standard length or not. It is practically impossible to keep a chain the standard length, that now used by the writer, one of Gurley's best tempered steel brazed chains, now being 66.58 feet, instead of 66 feet, as it was when first made. Where specified distances are required (which is seldom, if ever, in pine land surveying), the chain, if used, should be tested at the time with a good steel tape, and the proper correction made in the entire measurement.

If, in making his survey, he should find where some owner of adjoining land had cut across the line, whether in consequence of a line not properly run, or from any other cause, most lumbermen require the surveyor to measure the trees so cut, and report to them, which is done by measuring the diameter of the stump, or in case the butt of the tree is defective and left on the ground, the diameter of the top of the piece so left, the diameter of the top of the tree where cut off, which is the diameter of the top of the timber taken, and the distance between, which is equal to the length of the tree. This length he divides into logs of the usual length (as many 16 feet long as possible, the balance 12, 14, 18, or 20 feet), the diameter of the top subtracted from that of the butt. This number divided by the number of logs in the tree, and the quotient (as near as possible, avoiding fractions) added to the diameter of the tree, gives the diameter of the top end of each successive log. Then from his "log-book" or scale-rule, he puts down the number of feet, board measure, in each log, the sum of which gives the number of feet in each tree. He should mark a number on each stump in some substantial manner, cut with a "timber scribe" is the best, and mark the same number on his book for future reference, should his measurement be disputed. It has been the practice of the writer to make his report in a tabular form, giving in the first column the number marked on the stump; next, the diameter of the butt; then of the top, in inches; then the length of the tree in feet; and last, the feet, board measure, in the tree, or "scale," prefaced by a statement of the date of measurement, the date, as near as possible, of the trespass, what particular forty-acre lot, on which side, and stating that it was cut by parties lumbering on a specified piece of land, making the report in duplicate, and his employ-

ers usually keeping one copy in the office and sending the other to the parties who cut the timber (if known). They can, if so disposed, have the lines re-surveyed, and if found to be erroneous, throw out any particular tree without affecting the balance of the report, as well as test the measurement of each tree separately.

When going to camp, if the surveyor does not meet the "tote team" from that camp, or some other near, he must walk to camp, carrying his tools; and when done at one camp, he usually has to walk to the next, frequently through the woods, and without any guide but his hand compass, which the writer is never without, at home or abroad.

This class of work commences in the fall as soon as the camps are built, which is usually in September or October, so as to get the roads made and most of the timber cut and skidded before deep snow comes. Then when good sleighing commences, there is little to do but to haul the timber to the bank of the streams, ready to float to the mills in the spring. About all the calls a surveyor has after that, is in case the owners have reason to think some one has trespassed on their land. Of course, when the snow is deep, it makes hard and slow work, and as little of it is done as possible. This time varies with different seasons, from the middle of December to the first of February.

In the spring of 1887, a firm of Saginaw lumbermen ordered the writer to make a survey of a large tract of land which they owned. There were nearly 40,000 acres of it, located in townships 26 to 36 north, ranges 4 west to 5 east. In the whole tract there were only three whole sections. It was scattered through 272 different sections, in 43 townships and 7 counties. I had already surveyed enough to furnish two seasons' cutting, besides some that was cut over some years ago. As there were settlers all through the townships, and roads already made, I made no preparations for packing, but depended on going with a team wherever we went with the camp.

I bought one "two-men tent" for the cook and teamster, and one tent nine feet square with two feet wall, in which I slept with my two chainmen and two axmen. We put a pole across about 2½ feet from the front, held by stakes, for a "foot-board," leaving a space in front for "turkeys," boxes, boots, etc. For the bed, we picked a large quantity of hemlock twigs, keeping the stems together, then commencing at the head of the bed, laid a layer of them, then another a little back, with the stems on the ground, and the tops on the first layer, and so on till the ground was covered, when nothing was to be seen but the leaves on the end of the twigs. Over this, two strips of oil-cloth were spread, covering the twigs. Then the three beds were furnished with four pairs of blankets each. During the coldest of the weather we used three pairs of blankets over us and one under us, but most of the season, two pairs over us were sufficient. There were but very few nights

during the season that two pairs were too much, as the nights were nearly always cool.

To the front of the tent we pinned a piece of mosquito netting, doubled, with the bottom resting on a log which was staked against the front of the tent. This excluded the mosquitoes, but not the gnats. But by building a small fire in front, they were attracted to it and burnt, thus leaving us to enjoy a good night's sleep undisturbed. We had another "two-men tent," in which to store our supplies. We took a board sixteen feet long and sixteen inches wide, and cut it in the middle for a table, which made it eight feet long by thirty-two inches wide. We drove four crotches into the ground with sticks between each pair, under each end of the table. For seats, we drove four shorter crotches with sticks across under the table and a board on each side. At each end of the table was a crotch about nine feet high, with a pole from one to the other. Over this was thrown an awning nine feet by twelve, with ropes at each corner, which were tied to stakes about five feet high, thus protecting the table from rain or sun. An oil-cloth was spread over the table on which the dishes (of tin) and prepared food were left, and covered with another oil-cloth when not in use. The cooking was, of course, done wholly outdoors, the bread and beans baked in a "bean hole" dug near the fire, in the old "caboose" style. We had our mail sent to Gaylord, Otsego County, and when nearer some other office, had it forwarded to us.

I took the Saginaw Daily *Courier*, which kept us posted on the doings of the outside world; but sometimes we would be where we could not get the papers for a week or two, and at one time, three weeks, then we got them all at once.

We left Saginaw April 25, and returned Sept. 12. On Sept. 19, I went back to the lumber camps with one axman and two chainmen, and remained till Dec. 21, when the snow was too deep to work to advantage. April 30, 1888, I started out again with my camp equipment, and remained till Sept. 19, when I completed the survey of the land. I purchased most of my supplies in Saginaw, and had them shipped to Gaylord, where my team went for them. Some things (especially potatoes) I bought of the settlers. Potatoes are the principal crop raised by them, as they can raise potatoes with much less labor, and of a much better quality, than farther south. They expect (and usually get) a frost every month in the year, thus killing many weeds that trouble the farmer farther south.

J. H. LEAVENWORTH.

President.—"The object of the writer of this paper is not to instruct us how we should run a line, but it is to get into our report the ways of doing this work, and all those little attendant incidents which have occurred and are occurring, but which are fast passing away. The running of these lines will soon be a thing

of the past. It is and should be our object to gather together all these little incidents of what we might properly call pioneer work in this class of work, and all those little incidents of camp life which will soon be forgotten by many, and store them carefully up for future use as a history of how work was once done in our northern Michigan woods."

Mr. Rogers. — "I would like to ask how to get the length of a tree after it has been chopped, and the logs cut and removed?"

Mr. Leavenworth. — "I always instruct the man who holds my tape line to hold it just about where the butt has been cut off, and then measure to where the top is cut off; and then in estimating the number of logs, I never make calculations in odd feet, as I know that logs in the country are always cut in lengths of even feet, and never cut into odd lengths, so if there is a variation of a little, we can always get it pretty accurately."

President. — "I was employed at one time in finding out how much timber had been removed from a certain piece of land that was then in controversy with reference to a trespass suit. These lands were mostly covered at one time with pine timber, but there was scattered through it hemlock, beech, and other varieties of timber, so that we had a considerable timber to work among. It was our object to get every tree, so we had to be very careful in our work. I managed with two men besides myself, and with the aid of a pocket compass and blazes, to get every tree. It was quite a difficult task, at each time as we crossed the land east and west, in some places over a mile long, and others only a quarter of a mile long, to indicate our path by means of the blazes; and it was a great surprise to me that I could find the butt and top of every tree that had been cut, although it had been three years since the timber was removed. By observing very closely, any one can see by the splinters on the stump which way the tree must have fallen, and where it struck the ground; or what is the best guide of anything, the sawdust piles where each log had been cut off at intervals of the length of the logs; and by measuring the diameter of the butt and the top, and the number of logs taken off, you could calculate very closely the number of feet there must have been in the tree."

Mr. Leavenworth. — "I have generally made a practice, especially where there is much underbrush, of following log roads, and keeping either to the right or left; and I found I was always pretty successful in getting the trees by that means."

Secretary. — "I want to speak a few words on the subject of land surveying. I see many new faces here with us, and I have understood there has been a feeling of disappointment expressed by some on account of not having more papers on the subject of land surveying and kindred subjects. Of course, they do not understand the amount of this work that has been done by the

Society. When we first started out, our work was mostly on land surveying. Afterwards, on account of the large number of engineers joining our ranks, we devoted a considerable time to subjects of interest to civil and mechanical engineers, and so we have had to diversify our subjects as much as possible. About 40 per cent of our work up to this time has been in the direction of land surveying, while not that percentage of our members are simply land surveyors. We have traversed the ground so thoroughly in that line that it is very difficult to bring up any question on the subject of land surveying that would be new. When I was preparing a programme for this session, I sent out circulars to the members for topics on the various subjects, and out of that whole lot there was but one gentleman who suggested a topic on land surveying.

"Now there is but one thing that is of particular interest to me in that direction, and that is the decisions of the courts on points connected with our practice in land surveying.

"These decisions can readily be secured by the Society through the American Digest referred to in my report. While on this subject, it may perhaps be as well to call to your attention a recent decision of our Supreme Court. You will remember that at our last meetings I took occasion to criticise some of their decisions, particularly in the cases of Wilson *vs.* Hoffman, Keyser *vs.* Sutherland, Palmer *vs.* Dodd, and Commissioner of Thompson Township *vs.* Beebe.

"In the first case, it was decided that a fractional lot, as sold by the United States Government, could not extend beyond a quarter line. This was re-affirmed in the two following cases. Since my criticism of the doctrine was published, the Supreme Court has ordered a rehearing of the case of Wilson *vs.* Hoffman, and they have changed their former ruling on this point. Here is what they say about it, taken from the thirty-eighth 'Northwestern Reporter,' p. 558: —

"'In this case, when formerly here, the map of the original survey was not so certified as entitled it to be received in evidence, and there was nothing in the case as then presented that showed that the premises described in the declaration, came within the description of the S. E. quarter of Section 28. In the record before us this has been obviated, and the copy of the original plat of the township has been introduced, which shows, according to the Government survey, that the premises in question are embraced in what the Government denominated the S. E. fractional quarter of Section 28, in its patent to Tingley. It might perhaps have been more accurate to describe it as that portion of Section 28 lying south of Black River, but as the fraction contained less than 160 acres, and the law required it to be sold entire, the description contained in the patent was sufficient, and is quite

a customary method of description in the general land office. The conclusion of law which the court below arrived at, so far as it holds that the facts of this case as now disclosed are not contained in the claim embraced in the declaration, is erroneous.'

"It is gratifying to find that, like the Supreme Court of the United States, our own Court deems it better to break away from a precedent, or as in this case, from a line of precedents, than to adhere to an erroneous decision. Since coming here, I have taken pains to look up the original field notes of the section involved in the case of the Commissioner of Thompson Township *vs.* Beebe, and have also examined the full report of the decision in the case. The report does not disclose the fact whether or not there were two sets of section corners on the Range line, but from the surveyor's claim that his line was right, and that the quarter line as he ran it came out some ten or twelve rods from the quarter post for Section 36, one would naturally infer that there were double corners on the township boundary. Such, however, is not the case. The subdivisions were surveyed under the modern instructions, by which the closing lines of the survey are required to close on the standard corners. The line between Sections 30 and 31 was run west as a random line, to its intersection with the range line, and then corrected back for true line. Under these circumstances, I am disposed to accept the decision of the Court as correct, and to recall my former criticism, which was based only on the facts disclosed by the report of the case. I think the Court was right, and that as there is only one set of section corners in the boundary lines of townships, surveyed under the modern instructions, there should be only one set of quarter-posts."

Mr. Watkins. — "I differ with the Supreme Court and brother Hodgman in the matter. I say the Supreme Court is still in error, and I think I can show it to you. Supposing the section corners correspond, but the quarter post is not exactly in the center between them. I have sometimes found it half a chain out of the proper place. Now, if the Government survey is wrong, are we to perpetuate the error in another township because there is an error in the first? — I say most emphatically, No! But I think the subdivisions of each section should be made to depend upon the corners in that section. And where we find the measurement of either one of the lines over 80 chains, give each quarter half of it."

Secretary. — "The surveys in question were made under the instructions of 1855, and in these same instructions it is stated that there are to be double corners nowhere, except on the base and standard lines. Now we had no double corners there, and I cannot see how we can make any."

Mr. Watkins. — "The surveyors should do justice by the parties employing them, and where they have not made corners, we should make them."

Mr. June. — "If the east quarter post is here, and the new quarter post should be set east of it, and on land that is not in controversy at all, which shall be our guide?"

Secretary. — "It has been settled that the township boundary line, where it was run by the United States surveyor, shall be conclusive."

VILLAGE PLATS.

NEARLY every engineer is from time to time called on to make a survey, and plat the part or whole of a village. Those who have had experience, will not profit to any extent by my remarks, as they will be familiar with the subject from every stand-point. I have little reason to think that the members of the Engineering Society here had extra work to do because of the law, excepting myself. I have no doubt that your extensive practice was sufficient to enable you to take in at a glance all the fine points of the law, and consequently no plots were ever returned to you for correction or addition. With myself it was not so. My first attempt, although correct in my own mind, was not in harmony with the legal requirements as interpreted by our Auditor General. I afterward came to the conclusion that he and not myself was correct. These few words are written, then, entirely for the benefit of young engineers, and explain the process in detail, as concisely as possible. A circular containing the law and certificates can be had by addressing the Auditor General at Lansing. The process is as follows: —

Procure three sheets of muslin-backed paper, each 18 x 24 inches in size. The first of these will be termed the original drawing, and must be submitted for approval, as soon as completed, to the Auditor General. This must contain the certificate of dedication from the proprietor, a description of the land platted, and the surveyor's certificate. This, after being approved by the Auditor General, will become the property of the proprietor.

An exact copy of this plat, with the addition of a certificate of comparison to be signed by the Register of Deeds and the surveyor, for filing in the office of Register of Deeds of the county, must then be made. This second copy must contain a copy of the Auditor General's indorsement of approval. Still another exact copy must be made, containing all the certificates of the second copy, and in addition, one signed jointly by the surveyor and Register of Deeds, as to its exact agreement with the second copy. This is sent by the Register to be filed in the office of the Auditor General. The above is the general outline of the law, and should be fully comprehended before the details of construction are attempted. Indeed, I think most of the trouble experienced has come from not realizing the use and necessity of the three copies.

The details required are clearly set forth in the circular issued by the Auditor General, and I doubt that much trouble has been caused on that account. The principal on which these requirements are founded is the reasonable one that either map or description shall be complete in itself, and further, that a sufficient number of dimensions shall be put on the map to preclude any necessity of using a scale. This gives two or three checks on the correctness of the work, and would be valuable in detecting any error in any one of the methods. To carry this out, first our plat should show a complete and full description of the area to be platted; secondly, our map should be accompanied with a scale and meridian, and should show the location of all fixed monuments; thirdly, distances should be written on the map for each boundary line, for the width of lots and streets, and for the dimension of the scale. Our present law requires permanent monuments at all street intersections, and at each change of direction in the boundary line. The monuments at street intersections are not required at the center of the streets, or in any other specified position. The surveyor should use his judgment in locating his monuments, so that they will not be likely to be removed in making village improvements. The borders of the streets, or the curb lines, are not so likely to be disturbed as the center, and would answer every purpose in most cases.

It should be noted in making the second and third copies, that the law requires them to be exact copies of the original. This does not mean equivalent copies; and if the Register does his duty, every figure and word on the original must find its counterpart in the copies.

A form of certificate for the original and the copies can be had from the Auditor General's office. It would save much work if our prepared paper for plats could be had with these certificates printed in black on the sides. I believe there would be demand enough for each form to make the printing of them profitable. I would suggest that our worthy Secretary take the matter into consideration.

Just a word in regard to the appearance and construction of plats, and in this respect I will give you merely my own opinion. In the first place, these are merely maps, and clearness and distinctness should be the first and most important characteristic. The map should not be buried under a mass of pictures and fancy penmanship. The title should be clear and conspicuous, but not too prominent; and it would suit me better if plain. All the lines should be perfectly black, of even width, and thick enough to show well. The street names, figures, and dimensions should be neatly printed in black. I think no ink but a good quality of India ink, should be used for lines or dimensions. Tints can be easily applied, and if of neutral colors, will look well. As to a border, I prefer simply two plain black lines of different weights to any complicated arrangement of chains, vines, etc.

In regard to inks, I merely wish to say that liquid India ink of good quality can now be had. The Higgin's inks are the best prepared in this country, so far as I can find. These may be had in water proof ink for tinting over, or plain for other purposes. A French liquid ink, marked with two dragons, seems to be better than our American inks. The liquid inks are more costly than the stick inks, but are much more convenient to use, especially when no considerable amount of drafting is done.

PROF. R. C. CARPENTER.

HOUSE DRAINAGE.

THE progress of sanitary science during the last decade has been remarkably rapid. This has been largely due to a division of engineering labor and a concentration of the energy of able specialists in this field. No dwelling of any pretensions is now considered complete, or even looked upon with favor by a prospective tenant, unless it is fitted with "modern conveniences." These appliances are entirely proper and safe if the work is entrusted to proper hands. It is hard to conceive of a class of work, however, in which wrong methods or poor work are more detrimental, or the resulting influences more insidious.

In a paper of this kind, little more can be attempted than generalities. Methods of work are largely influenced by particular conditions. The condition of the public sewers, the methods employed for their ventilation and cleansing, and the rules of municipal Boards affecting the citizens, are all to be considered. The tendency at the present time is to refer work of this kind of any considerable magnitude, to specialists.

House drainage in its broader sense means both the removal of the liquid waste and whatever it carries with it, and also the removal of the subsoil water and storm water. Indeed, what is often spoken of as house drainage is strictly house sewerage. House drainage is the removal of water which has not been fouled.

The principal distinction between a sewer and a drain is that the former, being for the conveyance of foul liquid, should be absolutely tight, so that none of the contents may be lost by the way, and no vapors escape. A drain, on the contrary (as for instance a subsoil drain), must be laid with open joints, so that, the pressure being from without, it will receive the ground water all along its course, and remove it. The functions of the two are distinct. When both kinds of drainage are necessary, it is best to keep each system distinct. When a general system of sewerage is already constructed without regard to subsoil drainage, the householder frequently has no option but to connect the drainage system with the sewer proper. A very good method in such a case is to make the connection

through the medium of a deep seal trap where the street sewer enters the house. This connection should be through an iron pipe, properly calked into the trap, and provided with a brass-seated check valve which will prevent the sewage from filling the subsoil drains, in case the street sewer becomes obstructed. The subsoil drains should be of small agricultural tile laid well below the cellar bottom, and the joints properly protected. The sides and bottom of the cellar or basement should be thoroughly damp-proof. I am aware that this point is generally overlooked. We do not stop to consider that the earth below and about buildings is a great collector and retainer of filth, and that it is sufficiently porous to admit of the passage of air currents in considerable volume, especially under the influence of furnace draughts or other like causes. The action is not unlike what would occur if we suppose the house to be set on a sponge 50 x 100 feet, for instance, to which we constantly apply a stream of foul liquid, and then induce upward currents through the house by the action of heat. The cellar walls and floor can be very easily and cheaply made damp-proof and air-tight by a coating of some preparation of asphalt.

The main drain for ordinary dwellings should be four inches in diameter, and laid with as much descent as possible. The inclination should not be less than one in fifty. The method of connecting the main drain with the soil pipe depends upon the method of ventilation. The simplest method is to extend the main drain upward and out through the roof, unbroken by a trap in any portion. In this case it serves the double purpose of soil and ventilating pipe, and the air which passes into the street sewers at man-holes supplies the draught upward along the street sewers, and out through these and their upward extensions. In this case, the isolation of the interior of buildings from sewer air depends solely upon the trap under each fixture. Where street sewers are properly constructed on the "separate" system, and properly cared for, this method has proved entirely satisfactory. It certainly has great advantages in simplicity and facility of arrangement.

Where the sewers are built on the combined plan, the method of isolation shown in Fig. 1 is to be preferred. This diverts the foul air currents from the interior pipe, and provides a supply of fresh air for the upward current through the soil and ventilating pipe. If the street sewers are not properly ventilated at frequent intervals, either by the upward extension of exterior or interior unobstructed pipes or otherwise, there may be reasons for believing that an isolated one may draw from too wide a territory, and prove offensive. In this case, it is advisable to dispense with any vent pipe communicating directly with the sewer.

The main drain within or under the house and for a few feet outside of it should be of iron pipe with lead calked joints. It is better to fasten it along a wall by iron brackets or hangers above the cellar bottom, if possible, giving it as great an inclination as is

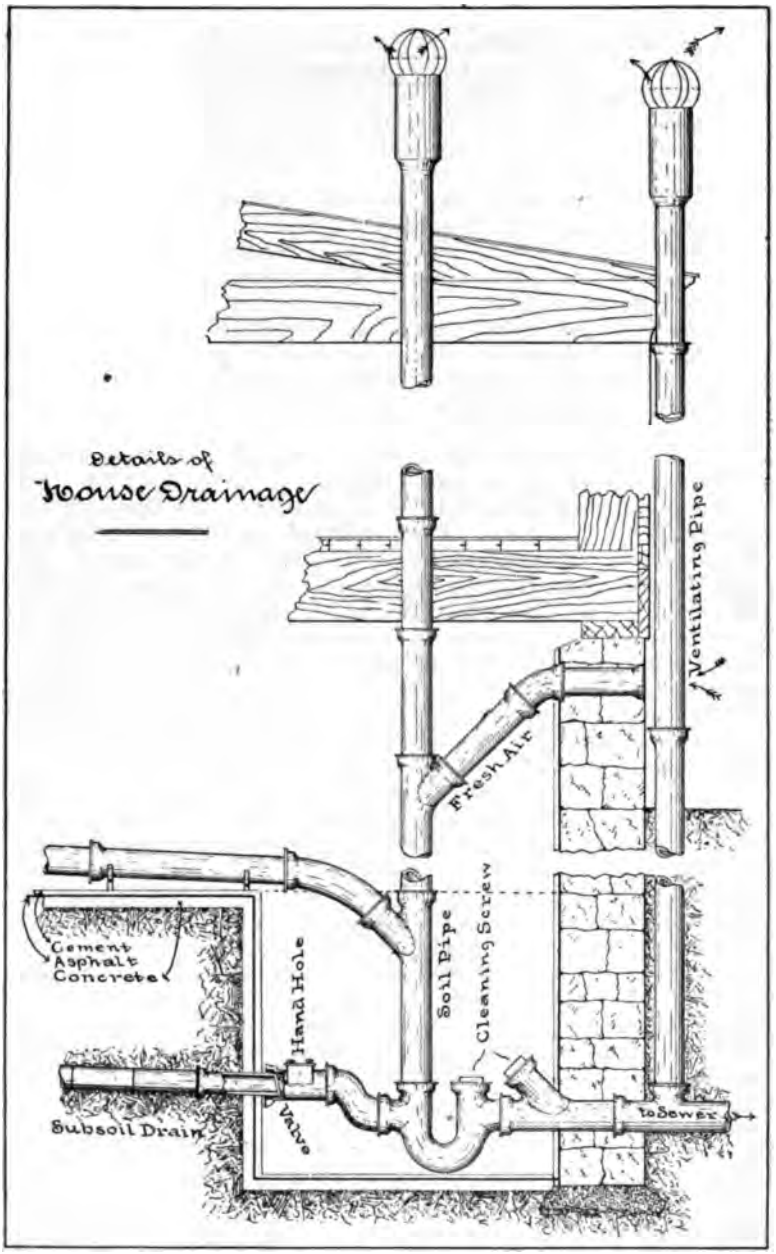
Details of
House Drainage
Ventilating Pipe
Fresh Air
Cement
Asphalt
Concrete
Hand Hole
Soil Pipe
Cleaning Screw
Valve
Subsoil Drain
to Sewer

FIG. 1.

permissible. In some cases it is necessary to place it below the basement floor on account of fixtures in the basement. This should be avoided if possible. Removable hand-holes or brass cleaning screws should be provided at intervals, through which obstructions can be removed. All iron pipes and fittings should be thoroughly coated outside and inside with coal pitch varnish applied hot.

A very common fault is to make the upward extension of the soil pipe, after it passes the highest fixture, of galvanized sheet iron, or even of tin. This is highly objectionable. It should be of heavy iron pipe throughout, and should extend well above the roof. It is a good plan to increase it in size above the roof to six inches, so as to lessen the danger of its being obstructed by the accumulation of frost. Ventilating cowls are of doubtful utility. A plain wire basket to prevent the introduction of articles liable to obstruct the pipes, is better.

There is such a variety of branches, curves, offsetts, traps, etc., etc., now in the market, that there is no excuse for awkward and rough connections and interior projecting angles or pockets which will retain the solid portion of the sewage. The course of all pipes should be as direct as possible, and the fixtures should be grouped so as to be reached as nearly as possible by upright soil pipes and short horizontal soil or waste pipes. Horizontal pipes cannot be carried any great distance along floors or ceilings or between joists, and preserve a proper inclination, for reasons which are obvious. It is customary to make waste pipes, particularly short ones, of lead, for the reason that it is much more easily manipulated than iron. The proper method of connecting the lead wastes to iron is by means of a brass thimble soldered to the lead pipe, and calked into a hub on the iron pipe.

It is a very bad practice to inclose plumbing fixtures with wooden casings, as is done in a majority of cases. It will surely tend to the accumulation of dampness and filth, and the emanation of unwholesome air. Unwholesome smells which are attributed to some faulty construction or arrangement in the drainage pipes, often have their origin in these inclosed spaces.

It is not uncommon in summer, when the air is loaded with moisture, to see water accumulate in bead-like drops on the surface of plumbing fixtures or pipes which are kept cool by a current of water from a tap, and course downward almost in streams. If the fixtures are not inclosed, they can be readily wiped dry. If inclosed, they receive no attention, and the accumulation of dirt and moisture becomes very offensive.

The better way is to have as little wood-work as possible surrounding these fixtures. The better kinds of water-closets are made so as to require no wood surrounding them, except a cover. A very good way to fit up wash-stands is to support the slab upon brackets fastened to the wall, leaving the under side entirely open, and the pipes,

traps, etc., entirely exposed, or partially hid by a narrow slab placed edgewise under the shelf proper, and extending downward about six inches.

So far as possible, it is preferable to have soil, waste, and ventilating pipes exposed, to having them inclosed within partitions, where they are inaccessible either for inspection or repair. This method of arrangement is not without its influence on the plumber. He is not less inclined to pour lead joints properly, or thoroughly to calk them all around, or to make neat and perfectly wiped joints, than when he knows that the carpenter or plasterer will cover his work within a few hours. I am aware that the average house owner will look upon this arrangement as decidedly lacking in finish, and not in harmony with interior decorations. Neither is a stove pipe, a furnace register, a steam radiator, or a gas fixture. This is largely a matter of education, and possibly we have been wrongly taught. It is not customary, however, to place these fixtures in rooms where any exceptions can be taken to this method of arrangement.

Plumbing fixtures should not be placed in sleeping rooms. They should be confined to the bath room, where special means of ventilation can be employed, and to the kitchen, laundry, and similar rooms.

A multiplicity of fixtures should be discouraged. A fixture rarely used is a greater source of danger than one used frequently.

Particular care should be used in arranging the ventilation of a building, so that the air currents tend to pass outward from the group of rooms containing plumbing fixtures, fresh air being admitted to other portions of the building. The facility with which this can be accomplished, and also the proper grouping of fixtures and simplicity of the system of pipes, will depend largely upon the architect. Ample means should be provided for flushing all portions of the soil and waste pipes and all fixtures. This is most effective when special flushing cisterns are supplied.

The ornamentation of porcelain ware and of surrounding woodwork by raised or carved patterns, is positively detrimental. A perfectly plain, smooth, impervious surface is more conducive to cleanliness. A very usual fault in house plumbing is too many fixtures, too much pipe, too much ornamentation. The owner may have perused the sanitary journals, or have heard some sanitary engineer talk sewer gas until he is thoroughly imbued with the idea that *here* is something which must be done thoroughly, and he not unnaturally comes to think that the more extensive the plant, the more sewer gas will be annihilated.

Every fixture should be provided with a trap, and since the object of the trap is to isolate the fouled interior surface of the waste pipe from the air of the room, it is evident that the trap should be as close to the fixture as possible. Notwithstanding many efforts to introduce a trap whose seal cannot be broken by

syphonage, and which will be self-cleansing, the plain-running trap of uniform bore is still in general use. This trap is liable to have its seal broken by syphonage, and to prevent this it is necessary to resort to a back air pipe, which is connected with the crown of the trap on the downward side, and passes to the roof independently of the ventilating pipe proper, or is connected with it above the highest fixture. This back air pipe should be of ample capacity to preserve the equilibrium of air pressure.

The system of back air vents is open to the following objections: It considerably complicates the system of piping, especially where fixtures are not closely grouped. There is a possibility of the pipes' being fouled at their junction with the crown of the trap. It adds considerably to the expense.

Back air vents tend to increase the interior circulation of air considerably. This is beneficial, so far as purity of the interior of the pipes is concerned, but it also increases the evaporation from traps. This will do no harm if fixtures are in constant use. On the other hand, if special anti-syphoning traps are used, and back vents are dispensed with, there will be little circulation of purifying outer air through the waste pipes.

When the soil, ventilating, and waste pipes are all in position, and before the fixtures are put in place, a test of the thoroughness of the work should be made. This can be done in a variety of ways. The following will be a very good test: Close up the main drain where the iron pipe terminates outside the house wall, also the exposed ends of all pipes where fixtures are to be connected, and the fresh air inlet, if there is any. The ends of lead pipes should be left somewhat longer than necessary, so that this can be conveniently done by flattening them, and closing with solder.

When all openings in the entire system of soil, waste, and ventilating pipes are tightly closed below, fill the entire system with water from above nearly to the top, and mark the hight at which the water stands. If no leakage is apparent, and the water stands at the same level for some hours, the joints may be considered good. The entire work should be carefully inspected while under pressure, and joints re-calked where necessary.

It is not proper to connect waste pipes from refrigerators or safes, or overflow pipes from water tanks or cisterns, directly with the sewers or waste pipes. The discharge from these can be often collected at a common receptacle, however, which is isolated from the sewers by special means.

For the purpose of getting a more comprehensive view of what we have sought to accomplish, let us review it briefly.

In the first place, we have secured a dry basement. This we have not accomplished by the ordinary method of an inlet into the sewer direct from the floor through a trap which is generally empty and provided with a removable strainer, which some servant will displace, and quite likely lose. On the contrary, instead of mak-

ing a hole in the basement floor, so that if it gets full of water, it can run out again (some day), we have sought to keep the level of ground water so low that the tendency will be in the other direction. It is well to design work of this class on the supposition that the worst will happen. Let us apply a few tests of this character, and note the probable behavior of our appliances. Assume, for instance, that it rains and continues to rain until the ground water rises considerably above the basement floor. The tile drains will remove it as rapidly as possible, and (the basement walls and floor being assumed impervious) there is no avenue by which it can enter. There is no trap or valve interposed, by the failure of which such an avenue can be established. The water-proof coating extends not only over the basement floor, but into the trap chamber, and surrounds the traps and soil and vent pipes like a dentist's rubber dam, entirely isolating the interior from whatever may be without. (See Fig. 1.) We may ride out the storm with all the confidence of a seaman in a dry ship. Suppose, again, that the main drain outside the house or the street sewer becomes obstructed. In this case, the tendency will be for the sewage to accumulate in the main drain and soil pipe, and be distributed and diffused through the subsoil drains. Its ingress to the subsoil drains will be prevented by the check valve. Suppose, however, that the check valve does not act, and that sewage is diffused through these drains. The house is still entirely isolated from it by an air-proof coating, and the danger reduced to a minimum. The check valve is readily accessible for inspection by removing a hand-hole, and its failure is not probable. If the stoppage remains unnoticed for some time, it will overflow at the lowest fixture, if there is one in the cellar, and if not, probably it will overflow at the fresh-air inlet outside, if there is one.

If the pipes or traps become obstructed, they are all readily accessible without damage to partitions or floors.

I recall an instance where a party built a ten-inch main drain for a small house which would have been amply served by one of four inches in diameter. An untrapped pipe was left open at the basement floor, so that water might not accumulate in the basement. The wisdom of this procedure became apparent later when the house was completed, and it became evident that the main drain and the cold air duct supplying the furnace had been combined. A pipe four inches in diameter is too small for this purpose. The system outlined in Fig. 1 makes no pretensions to a "general purpose" utility.

If roof water is admitted directly to the sewers, the rain-water leader should connect with the main soil pipe directly above the main trap. No waste or soil pipe should be connected with the rain-water leader. In a great many cases it will be advisable not to discharge the roof water into the sewers, particularly in the case of isolated dwellings where a portion of it is retained by cisterns,

and where lawns are of considerable extent. In the case of more compactly built city buildings, it will often be best to allow the roof water to be discharged into the street gutters, especially where these are properly arranged, and the descent is sufficient.

The following table of the behavior of house drains when running three-fourths full, was calculated by Robert Moore, C. E., of St. Louis, Mo. : —

TABLE OF DIAMETERS OF HOUSE DRAINS.

With various grades, and for lots of different sizes, capable of discharging two inches of rain per hour, when running three-fourths full.

Calculated by Robert Moore, C. E., St. Louis, Mo.

SIZE OF LOT IN FEET.	FALL PER 100.						
	1.0	1.5	2.0	2.5	3.0	4.0	5.0
	DIAMETERS IN INCHES.						
20 x 150	3 1/2	3 1/4	3	2 7/8	2 3/4	2 5/8	2 1/2
25 x 150	3 5/8	3 1/2	3 3/8	3 1/4	3	2 7/8	2 3/4
30 x 150	4	3 7/8	3 3/4	3 5/8	3 1/2	3	3
35 x 150	4 1/4	4	3 7/8	3 3/4	3 5/8	3 1/2	3 3/8
40 x 150	4 1/2	4 1/4	4 1/8	3 7/8	3 3/4	3 5/8	3 1/2
45 x 150	4 3/4	4 5/8	4 1/2	4	3 7/8	3 3/4	3 5/8
50 x 150	5	4 3/4	4 5/8	4 1/2	4	3 7/8	3 3/4
60 x 150	5 1/2	5 1/4	5 1/8	4 7/8	4 3/4	4	3 7/8
70 x 150	5 7/8	5 5/8	5 1/2	5 1/4	5 1/8	4 1/4	4 1/8
80 x 150	6	5 7/8	5 3/4	5 1/2	5 3/8	4 5/8	4 1/2
90 x 150	6 1/4	6 1/8	6	5 3/4	5 5/8	4 7/8	4 3/4
100 x 150	6 1/2	6 3/8	6 1/4	6	5 7/8	5	4 7/8

By an inspection of the table, we see that a four-inch main drain is ample for any ordinary condition of service, even if roof water be admitted, the discharge of house sewage proper being only a very small percentage of the total volume. A smaller size than four inches is not to be recommended, however, for the reason that although it may be ample so far as estimated carrying capacity is concerned, it is more liable to obstruction. Under some circumstances, it may be advisable to increase the size of the main drain to five or even six inches' diameter; this limit should not be exceeded, however. If one drain of this size is not ample, it is better to increase the number.

GEO. S. PIERSON.

President. — "I suppose that this contemplates an abundant supply of water, and pressure sufficient to cause all these sediments to disappear; but I think for a common place or farmer's house, such as we generally find throughout the State of Michigan, there would be no greater convenience than to be able to take

away the kitchen slops without injury to the room and without the necessity of going out-of-doors."

Mr. Foster. — "The trouble with the kitchen slops and all that kind of stuff is that you can have good tiles and drains, etc., but they will get stopped up every time. I have tried a great many plans, but I think I have never been fortunate enough to find anything to displace the old 'slop pail' successfully."

Mr. Appleton. — "I think the best way is to take it out in a pail, and throw it out on the ground, scattering it over a considerable area, not throwing it into heaps."

Mr. Watkins. — "I have no system of house sewerage on my place, but I have a pail, and when it gets full, I carry it to the garden gate and throw it onto the garden, and every rain that comes washes it over the ground, so that there is never any bad odor arising from it."

Mr. Foster. — "In the city of Nottingham, Eng., they pump it up to the top of a hill, where it is distributed all over the adjacent country; and I can just tell you the crops they raise on those grounds would surprise you, the system keeping it enriched continually."

Mr. Appleton. — "And I would just say that is a pretty good paying thing, as it is not so expensive as one would naturally think it to be."

Mr. Wells. — "In small sewers, where the obstruction is caused mostly by the grease sticking to the pipes, I find that by pouring a little ammonia into the pipe occasionally, it will keep it clean."

Prof. Greene. — "If you will stir up a half pail of ashes with some water, and let it stand awhile until there is some strong lye, and pour that into your pipe, you will find it will clean it out pretty effectually."

Prof. Cooley. — "We have made a practice of spreading our coal ashes over our slops after being thrown into the back yard, and I have never noticed any odor from them."

APPLICATION OF PHOTOGRAPHY TO SURVEYING AND ENGINEERING PURPOSES.

To the President and Members of the Michigan Engineering Society :—

THE recent progress in photography has made it an indispensable aid in nearly all of the arts and sciences. In engineering and surveying, it should receive attention as one of the most important means of improved practice in field work, until the camera is as familiar to the profession as the compass and transit.

But a few years ago the practice of photography in the field was limited to exceptional conditions, on account of the cumbersome outfit required, and the tedious processes involved in the

preparation, exposing, and developing of the wet plates used, on the spot where the observations were made. The skill of the professional photographer was, in fact, required to obtain satisfactory results.

These difficulties disappeared with the invention of the modern dry plates, which can now be procured at reasonable prices; and the best results can be secured with the exercise of ordinary skill, while the records obtained in the field can be kept indefinitely before developing, which may be done at home, in the evening, or during any convenient interval of leisure. The lenses used in the portrait galleries are unsuited for such work, as they give a distorted image that does not permit a quantitative comparison of the different parts of the field of view.

Aside from the camera and lenses which are needed for accurate work, but little apparatus is required, and that simple and inexpensive.

So far as the wants of the engineer or surveyor are concerned, the art of photography can now be learned in a few days' practice, if reasonable attention is given to a few simple details of manipulation.

Dry plates are now made so sensitive that good results may be obtained with even a moderate amount of light. Interiors and foundations may now be photographed at night by means of the magnesium light, as readily as in the most favored localities in broad daylight; and it is even difficult to imagine conditions that would prevent the satisfactory application of the art.

There are many applications of photography that will be readily suggested to the practical engineer. Aside from the copying and enlarging or reducing of maps and plans, by means of bromide paper prints, or the blue print process with which you are all familiar, we will ask your attention to the relation of photography to field work. In engineering constructions and buildings, a record of every detail of the work, from foundation to completion, can readily be made. The value of such permanent record in checking estimates, or in the study of any special features of the work, can hardly be overestimated. It is important that the photographic record should be made by the engineer himself, so that the strict conformity to a scale may be clearly observed. Without further examples, the utility of photographic methods of recording the progress of constructing details, must be fully appreciated.

In surveying, it will at once be suggested that a photographic record of monuments with their surroundings, will be convenient for future reference, and in cases of disputed boundaries, may be valuable as evidence. The latest applications of photography in topographical surveying are, however, of the greatest interest, as the new method of field work with the camera has the advantage of making a perfect record of every detail of the field surveyed,

while it furnishes the required data for a map on a horizontal plan, with an exact representation of every elevation and depression.

The mathematical and mechanical principles involved in photographic surveying were discussed by Col. Laussedat, of the French Engineers, as early as 1858, and they were soon afterwards applied under the disadvantages of the old wet plate process with remarkable success. In 1864, M. Javary made a photographic survey of Grenoble and suburbs. It agreed closely with the regular survey made by the engineer in charge of roads and bridges, the differences in level nowhere exceeding 19 inches.

Meydenbauer, in Germany, about the same date, "made a photographic survey of Fribourg and suburbs, plotting to a scale of $\frac{1}{1000}$ with ten-foot contours. The field work required two days; there were six stations and twenty-one plates; the plotting required eighteen days, and the resulting map was accurate in every respect. In 1874, M. Javary made in one day a photographic reconnaissance extending fourteen miles, and embracing the features for a distance of from one to two miles on each side of the route. And on another occasion he executed in fourteen hours the field work and plotting of a complete and exact map, including the leveling of a zone three-fourths of a mile in breadth; and this in rainy weather, and with wet plates."

Experiments made in 1878–80 brought the gelatine-bromide emulsion plates into notice, and since that time the process has been perfected and brought into general use. These dry plates are exceedingly rapid, and the simple manipulations required in their use leaves nothing to be desired in their applications to photographic surveying. In 1887, Lieut. Reed, of West Point, "made, with dry plates, a photographic survey of a tract containing about twenty-seven square miles; three principal and two auxiliary stations were used from each of which four or five views were taken. The field work occupied ten hours; and with a little more previous experience, the plotting, including the leveling, could have been readily performed in two or three days. For the leveling, about 100 points were determined from the views, and most of these points, in plan, construction, and leveling, checked exactly." According to Col. A. C. M. Pennington, U. S. A., in surveys made by this method in Savoy, "one survey of eighteen days' field work sufficed for 30,000 acres, contour lines being mapped five meters apart, giving five months' office work. In another case 110 proofs were taken for 20,000 acres, the field work consuming but fifteen days."

The advantages of this method of surveying are obvious. While the work is rapidly performed, there is a complete record of every detail of the field in both plan and elevation, so that accuracy is secured, under a multiplicity of checks against possible error.

The leading principles involved in this method of surveying may be briefly stated as follows: A landscape photograph, if made with a rectilinear lens, is a true perspective, in which right lines are shown as right lines, and curves as curves, each in due and fixed proportion to the original.

When the picture is taken, the camera must be carefully leveled in two directions, and a vertical plane through the optical center of the lens may be taken as a base line from which the angular distance of any point may be measured in a horizontal direction.

A horizontal plane in like manner projected through the optical center of the lens may be taken as a horizon from which the angular distance of each elevation and depression may be determined.

The key to these angular distances, either horizontal or vertical, is the equivalent focal distance of the lens combination, which must be carefully determined, and taken as radius in measuring the angles, by a protractor or a table of natural tangents.

It has been recommended in actual field work to measure a base line, from each end of which the entire field to be surveyed can be seen. From the ends of this line the bearing of several points in the field that can be identified on the photograph, may be taken with the compass, and this will serve as a skeleton plan when placed on paper, to aid in the plotting.

Two or more views should be taken with the camera from each end of the line, as it is necessary that each point of the field should appear on at least two plates. In plotting, the ordinary method of intersections is applied in fixing points on the plan, very much as in plane table surveying.

It is unnecessary to go into details in regard to field work and plotting, as these will be fully described in the works you will need to consult in applying the method in practice.*

Special forms of the camera have been devised for photographic surveying, but on the whole, the common camera will probably be the most satisfactory. It should be well made, with a rigid vertical front and back, so that the optical center of the lens will always coincide with the same point on the focusing screen. A "rising front" will be found convenient in adjusting the optical center of the lens to the wire that serves to record the horizon. The camera should revolve on a spindle fixed to the top of a tripod with leveling screws. A round disk of board, with graduated edges, fixed to the top of the tripod, will be found con-

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* References: "Photography Applied to Surveying," by Lieut. H. A. Reed, West Point, John Wiley & Sons, 15 Astor Place, New York. 4to; cloth, $2.50. This is probably the best and most comprehensive work on the subject.

"Topographical Drawing and Sketching," including applications in photography. Same author and publishers. $3.50; new edition, $5.00.

An article by Lieut. Reed, on "Photography Applied to Surveying," and another by Col. A. C. M. Pennington, U. S. A., on "Photography Applied to Military Purposes," printed in "Anthony's International Annual." Paper, 50 cents; cloth, $1.00.

venient to indicate the angle from the base line at which the view is taken.

A fine horizontal wire should be placed in the plate-holder, in the plane of the optical center of the lens, so that it will be in contact, or nearly so, with the plate when exposed, and thus record the horizon from which elevations and depressions are measured. A fine vertical wire in the plane of the optical center of the lens, and similarly placed in relation to the plate, will also be of assistance in orienting the views on the map.

A detached level will serve in adjusting the camera, which must always be leveled in two directions when the views are taken. Accuracy in all of the adjustments, as in the case of other engineering instruments, is essential to exact work.

As to the size of the camera, no definite rule can be laid down, as much depends on the character of the work. The larger plates are of course more cumbersome, and they not only cost more, but are also more difficult to manipulate. On the other hand, they have the important advantage of giving the views on a larger scale, so that greater accuracy may be secured in measuring and plotting.

Cameras for 5 x 8, 8 x 10, or 10 x 12-inch plates may be used, but the first mentioned is too small for any but limited areas. Taking everything into consideration, my impression is that 8 x 10 plates will be found most satisfactory for ordinary field work, and the camera for this size of plates need not be so heavy as to be objectionable on that account.

Only the best lenses should be used, and these must be of the rectilinear type. The ordinary portrait and landscape lenses give a distorted image that is not noticed in a portrait, but which entirely unfits them for architectural work or field surveying. It will be poor economy to buy a second-class lens, even if it is rectilinear, as it will fail to give the best results under unfavorable conditions of light. The lens must of course be adapted to the camera and the size of plate used, and as a general rule, its equivalent focal distance should somewhat exceed the longest diameter of the plate.

A lens of shorter focus, or a wide angle rectilinear lens, may be needed in circumscribed localities, where the long focus lens, best adapted to field work, cannot be used.

The equivalent focal distance of each lens should be accurately determined, as this is an essential factor in plotting from the negative.

There are many brands of dry plates now in market, and there is but little choice among the leading makers, as Stanley, Carbutt, Seed, etc. It will, however, be best to use but one kind, as each brand has its peculiarities in regard to development and exposure, and when one becomes thoroughly acquainted with the behavior of his plates under different conditions, he can obtain the best

results from them, when he might fail with a new brand that needed slightly different treatment.

Of the many developers now in use, the new hydroquinone will undoubtedly prove the best for all purposes, and it can now be obtained at a price that makes it the cheapest, as well as the best.

With a little experience, many applications of the art will suggest themselves. For example, a true meridian may be readily made with the camera. On a bright, star-light night, the camera may be carefully leveled and pointed approximately north, and a rapid plate may be exposed for several hours. The circumpolar stars will describe arcs on the plate, and the landscape beneath will also be copied. When the centers of the arcs are graphically determined, and radiuses drawn from them, the radius that is vertical will be on the true meridian, and it may be produced to indicate the required point on the landscape.

For photographing foundations or interiors, or copying at night, a magnesium flash light may be used with rapid plates.

DR. MANLY MILES.

DESIGN FOR PIER ON SOFT GROUND.

THERE are nearly 14,000 linear feet of timber pier at the St. Mary's Falls Canal. About one-third of the pier was built in place when the water was out of the canal, and the remainder was built in the form of cribs, and then sunk in place. Four spuds, one at each corner of a crib, being used to keep it in alignment, and the top nearly level, a continuous superstructure four feet high was built on the cribs.

No trouble was had in regard to a solid foundation, as the greater portion of the piers rests upon sandstone, bedrock, or hardpan, the principal exception being a section of the pier 200 or 300 feet long a short distance above the lock. After the excavation had been made for the pier side, there still remained a pocket of quicksand from two to seven feet deep on the sandstone rock, over which a line of continuous pier was built in place in March, 1881.

The method adopted was simply that of placing a platform of two-inch planks, six feet long, transversely under the front and back walls of the pier, and in order to allow for settlement, the planks were placed about four inches above grade. At present it is from one to three inches lower, but its alignment is as good as that of the adjoining piers. Last year the construction of the pier in front of Fort Brady military reservation having been determined upon, plans and specifications were prepared.

A shoal extended about 150 feet in front of the line adopted as the face of the pier. On the pier site the depth of water varied from two to twenty-nine feet. The material of the shoal was composed of silt, quicksand, and stones, and over 32,000 cubic yards were removed to a depth of twenty-one feet by dredging.

The location is such that there will be no heavy seas to withstand, so that in order to provide a proper foundation for securing stability and permanence of the cribs, it was only necessary to consider the pressure against it as a retaining wall, and the blows it might receive from passing vessels. It is possible that the pier and the area back of it may be used for a stone-yard during the construction of the proposed new lock.

The general plan of the crib is a modification of those forming the breakwater at Chicago and other Lake Michigan harbors. The principal changes are in the method of framing the ties, and in arranging the bottom course so that the side walls are directly over the bearing piles, thus making a somewhat stronger form of crib.

The cribs as designed are fifty-six feet long, twenty feet high, and twenty feet wide, except the bottom course, which is twenty-two feet wide. The timbers for the two upper courses of the cribs and the four courses of superstructure are to be of white pine, and that for the rest of the crib will be of hemlock. Each crib rests on fifteen bearing piles. To insure a true bearing on the piles, the bottom is made of three horizontal surfaces, each three feet wide, extending the full length of the crib, and corresponding in position to the rows of piles.

The cribs are built with tight sides. The cross walls are eight and one-half feet apart, each alternate one being solid, and the others with a foot of open space between the ties. Half way between the cross walls are grillage timbers at top and bottom. The timbers are twelve inches square, and carefully framed and firmly bolted together. The open bottom of the cribs allows the stone filling to pass through and form a solid base for the cribs to rest upon; and additional stability is given by triangular-shaped pockets in the end compartments; the apex of the triangle being down and next to the end walls.

Stones will also be placed in front of the pier to a hight of one foot above the top of the piles.

The contractor for excavating the lock pit will be required to fill the area between the pier and the shore line up to the level of the top of the pier. For a distance of twenty-five feet back of the pier, the filling must be of stone. The bill of materials for one crib is as follows: —

WHITE PINE. — IN SUPERSTRUCTURE AND UPPER TWO COURSES OF SUBSTRUCTURE.

1	piece	timber,	1 x 1 x	34	feet	34	cu. ft.
10	"	"	"	32	"	320	"
3	"	"	"	30	"	90	"
2	"	"	"	26	"	52	"
15	"	"	"	24	"	360	"
1	"	"	"	22	"	22	"
35	"	"	"	20	"	700	"
16	"	"	"	16	"	256	"
2	"	"	"	14	"	28	"
	Total					1,862	"

HEMLOCK. — IN SUBSTRUCTURE.

4	pieces	timber,	1 x 1 x	34	feet	136	cu. ft.
21	"	"	"	32	"	672	"
10	"	"	"	30	"	300	"
10	"	"	"	26	"	260	"
30	"	"	"	24	"	720	"
17	"	"	"	22	"	374	"
64	"	"	"	20	"	1,280	"
28	"	"	"	18	"	504	"
30	"	"	"	16	"	480	"
8	"	"	"	14	"	112	"
	Total					4,838	"

IRON.

557	drift bolts,	1" ○ x 34",	wt.	$7\frac{32}{100}$	lbs.	4,189	lbs.
39	" "	1" ○ x 22",	"	$5\frac{16}{100}$	"	201	"
28	screw and washer bolts	$1\frac{1}{8}$" ○ x 39"				368	"
7	" "	" "	"	$1\frac{1}{8}$" ○ x 27"		69	"
	Total					4,827	"

15 piles, 32 to 45 feet in length.

The specifications are as follows : —

Description of Work. — The work to be done under these specifications comprises the construction of about 1,460 linear feet of pier. For this purpose the contractor will be required to furnish about 34,000 cubic feet (more or less) of white pine timber, and 96,000 cubic feet (more or less) of hemlock timber, 390 piles (more or less), and 89,000 pounds (more or less) of bolts; also to drive and saw off to grade 390 piles (more or less), to frame and place in the pier about 175,000 cubic feet (more or less) of pine and hemlock, and to fill the pier with about 22,000 cubic yards (more or less) of stone.

Locality. — The pier is to be placed in the St. Mary's River, in front of Fort Brady, Mich. A dredge, cut in which there is about twenty-one feet of water, has been made for the pier site.

CONSTRUCTION. — The pier will consist of wooden cribs built separately, then placed on a pile foundation, and filled with stone; next, a continuous superstructure will be built over the whole length of the pier; and, finally, the pier will be filled to the top with stone. Drawings illustrating the location and construction of the pier may be seen at the U. S. Engineer office at Detroit or Sault Ste. Marie.

The piles must be in the places indicated in the drawings, and they must be driven until a hammer weighing 2,000 pounds and falling fifteen feet will not drive the pile over one-half inch. After they have been driven, they must be sawed off so that their tops will be in a horizontal plane seventy-eight and one-half feet above canal datum (which corresponds to a depth of water of twenty feet). The top of each pile after being sawed off must be within one foot of the place indicated in the drawings. If any settling occurs after the cribs have been placed on the piles, leveling pieces, cut and framed to dimensions furnished by the United States agent in charge, must be added before the superstructure is built.

The ends, and the length of the two cribs at the northwest angle, may be varied. Special drawings will be furnished for these cribs and their superstructure.

FRAMING AND BOLTING. — The manner of framing and bolting, the position of ties, etc., must be as shown in the drawings (except that at the option of the United States, the upper six courses of the pier may be varied so as to give a batter of six inches). The workmanship of the framing and bolting of all parts must be as good as the best work of the existing piers of St. Mary's Falls Canal.

The diameter of the holes for the drift bolts must be one-eighth of an inch less than the diameter of the bolts, and the holes must be bored the whole distance that the bolts are to be driven.

PLACING CRIBS. — Each crib must be so placed on the piles that no point in its face shall be more than two inches out of alignment, and that the space between the ends of the cribs shall not be greater than one foot.

FILLING. — The cribs and superstructure must be filled to the top with closely-packed stones.

MEASUREMENTS. — The timber, piles, and bolts furnished by the contractor will be measured and estimated on delivery. The framing will be estimated by the cubic foot as measured after being framed and bolted in the pier. The stone filling will be estimated by the cubic yard after it is deposited in the pier.

ORDER OF WORK. — The order in which the work shall be prosecuted will be determined by the agent of the United States, whose instructions in all matters relating to the work must be conformed to by the contractor and his employees.

TIME. — The piles must be driven (through the ice) before the 15th of April, 1889. The remaining work must be begun before

June 1, 1889, and completed before Nov. 1, 1889. From the beginning, the monthly rate of progress shall be, at least, equal to the average monthly rate required to complete the work within the specified time.

GENERAL REQUIREMENTS. — Any timber, iron, or material of any kind, unnecessarily wasted by the contractor, will be charged to him, and deducted from his next succeeding estimate. Any stone or other material dropped into the canal or about the pier, by the contractor, must be removed by him without cost to the United States. No extra work of any kind will be paid for, unless specially ordered in writing. All drawings cited in explanation of these specifications are considered to form a part thereof.

TIMBER. — The white pine timber must be sawed accurately, free from splits, shake, rot, blackknots, wane, or other imperfections.

PILES. — The piles must be of hemlock, or other equally suitable timber; they must be straight and sound, and at least ten inches in diameter at the smaller end.

IRON BOLTS. — The drift bolts are to be made from an approved quality of round iron, one inch in diameter, blunt pointed, and with round heads one and one-half inches in diameter. The screw and washer bolts are to be of similar round iron one and one-eighth inches in diameter. (A drawing will be furnished the contractor, showing the form of all the bolts.)

OFFERS. — Bidders must state the price per unit for the several classes of materials and work separately, but the aggregate, determined from the pieces and the approximated quantities, *will* be considered as one bid.

PAYMENTS. — Payment will be made monthly, reserving ten per cent from each payment until the completion of the contract.

There were eleven bids received; the lowest and highest being as follows: —

	White pine timber.	Framing white pine tim.	Hemlock timber.	Framing hemlock timber.	Furnishing piles.	Driving piles.	Drift bolts.	Stone filling.
	cu. ft.	cu. ft.	cu. ft.	cu. ft.	each.	each.	per lb.	cu. yd.
Lowest Bid	.24c.	.07	.13½	.07	$3.00	$4.00	.03c.	.48
Highest Bid	.30	.05½	.20	.06½	4.50	4.00	.07	1.50

Rate per linear foot of pier, $39.55, and $64.38 respectively.

JOSEPH RIPLEY.

MEASUREMENT OF A PRIMARY BASE.

In 1841 was begun what has since turned out an immense, complete, and most satisfactory work; namely, the survey of the great chain of inland lakes of North America, by the United States Government. It was carried on for forty years, the final charts not being out until 1881. The work was under the charge of the War Department, the immediate supervision being, at first almost exclusively, in the hands of Corps engineer officers, but later, as the scope of the work enlarged, and more engineers were necessary than could be spared from the Corps for this purpose, civilian assistants were added. Many of these latter were with the survey for years, and to some of them is due especial praise for the methods and suggestions in carrying on the work, in particular, the wonderfully careful result in Base Line work, shown in the Reports of E. S. Wheeler, who now, by the way, has charge of the Government work at the "Soo," under General Poe.

Previous to 1852, when for the first time our Government published three charts of parts of Lake Erie, there was absolutely nothing in the way of printed help for American Sailing Masters; for although even before this time, Bayfield, of the Royal British Navy, had done a great deal of really fine work in data for accurate charts, considering the rough methods and rapid reconnaissances that he in person must have made to cover the ground and water that he did, and in the time he did, these were not allowed out of the hands of the British Admirality, and our brave navigators of even up to a few decades back, knew best where a sunken rock was when it had punched a hole in their wooden bottoms.

The survey was started under a Government appropriation of $15,000, and at a time when a vessel leaving Chicago found no shelter until reaching the Manitou or Beaver Islands, and after passing the Straits of Mackinaw and Presque Isle, no harbor, until considered safe in St. Clair River. Even then she had to pass the dangerous fishing "Flats" before she reached our goodly city of Detroit.

With one exception (1847), Congress made yearly appropriations of sums varying from $15,000 the first year, to $175,000 each year from 1871–74. In the aggregate, for the forty years, and until the survey was completed, the appropriations amounted to $2,927,000. That this sum was in the main honestly and carefully spent, can be seen in the published charts, for they are as full and as complete as can be desired, and on them one can measure 6,000 miles of shore line. Thus for less than $500 per mile was the great survey made, and at an average rate of 150 miles per year. This is an odd way of figuring up such work, but still it is pertinent.

From the start, a general Geodetic Survey of the entire chain of lakes was contemplated, but owing to the meagerness of the ap-

propriations during the earlier part of the work, the actual operations were confined to localities where improvements were called for, or where navigation was specially difficult. Thus the small moneys were expended for preliminary surveys at these particular localities because of the pressing need of improvements, and the purchase of larger and finer instruments necessary for the more extensive and exact work was deferred for many years. These instruments, finally obtained mainly through the efforts of Gen. C. B. Comstock (who had charge of the survey from the spring of 1870 until its completion in 1881), were as fine as the world could produce. The Bache Wurdeman Base Line Apparatus, however, which I wish particularly to describe, and to which is due the exactness of the work, even to the determination of questions as regards the precise form of our world, was purchased as early as 1852, when Capt. J. N. Macomb was in charge.

It was constructed by Mr. Wm. Wurdeman, of Washington, under the direction of Capt. Thos. J. Lee, of the Topographical Corps, and was in all essential particulars similar to that made the previous year for the coast survey, but modified for the purpose of being lighter, smaller, and more delicate.

It is a contact apparatus, the measurement being made with two tubes, each consisting of an inclosed tin case containing two bars, one of iron and one of brass, firmly joined together at one end, and carrying at the other a compensating lever, so constructed that the tube shall have nearly the same length at all temperatures. The bars are each 168 inches long, the iron, 1.40 inches high and .27 inches wide, is immediately over and three tenths inches distant from the brass one, which is 1.10 inches high, and .37 inches wide. To the front end of the brass bar is hinged a vertical compensating lever, having on its rear side a knife edge which is pressed by a spring against a steel plate on the front end of the iron bar, while higher up another knife edge on the front face of the lever has constantly pressed against it a sliding rod, whose forward end, armed with an agate plane, projects from the front of the tin case, and forms one measuring end of the tube. The object of this lever, made as it is with the distances of the knife edges from each other, theoretically determined to correspond with the expansion of the two different metals, is to make the distance between the end points of the tubes during changing temperatures, constant, so long as the two bars have the same temperature. At the rear end of the tube, a vertical arc for measuring inclination is fixed to the upper bar, and is read by a vernier with a level on its arm, called the sector level, the horizontal axis of the vernier being perpendicular to the plane of the bars. The vernier arm carries a small cylindrical surface, the axis of which coincides when in adjustment with that of the vernier, at the instant the bubble of a small contact level moved by the same arm bearing the cylindrical surface, plays. Against this surface abuts

a brass rod, armed at its outer or rear end with an agate knife edge, and, projecting through, forms the rear measuring end of the tube. In guides, this rod has an end motion only, and when the tube is not in contact with its mate, is forced out by the counter balance on forward end of contact level. In measurement, the base line, which for primary triangulation is chosen on ground as near level as possible, and from four to six miles long, is carefully marked by stakes, and these stakes by scratches obtained by a theodolite placed in the vertical plane passing through the ends of the base line. The first tube is placed in line (by means of two theodolites) on carrying trestles, which in turn rest on iron pins, driven into the ground. The rear trestle has three legs, and is provided with a tri-rectangular head motion, while the forward one has only two legs, with head arranged for only a vertical and cross motion. By one of these slow motions on the rear trestle (the longitudinal), the tube is brought into place, so that the rear agate knife edge is, when forced in until the contact bubble plays, exactly over the minute marking on the metal button, firmly leaded into the base line end stone. This is done by the help of a theodolite placed at right angles to the base line. The second tube is now brought into place, the rear end by the various motions of the trestle head made ready for contact, and the forward end adjusted in line by a theodolite ahead. Contact is made by the longitudinal slow motion, the rear knife edge of the second tube being forced against the rigid plain agate in the front end of the first tube, until the contact level plays. Then the contact level, the sector level, the sector arc, and three very delicate thermometers inside of the ends and center of the tube, are read by two independent observers. Contact is then broken, the rear or first tube with its tent being brought back away from the second, and carried around and again aligned in front of it, and the work continued. To facilitate this, an extra set of trestles are used, to provide for there always being a set ahead in which to place the next tube. The iron pins on which the trestles stand are properly driven and leveled by means of trial bars corresponding to about the positions the trestles will have to take when holding the tube.

In order that no direct radiation of the sun may affect the tubes, portable frames, covered with canvas, and large enough for the observers to work under, are at all times carried over each tube. When, at night for instance, it becomes necessary to stop work, a theodolite is set up about ten feet from the forward end of the forward tube, and another approximately in a vertical plane through the end of its agate, at right angles to the line. By means of these theodolites, a mark is made directly under the agate, on the head of a copper tack in a stout peg, the top of which is driven below the surface of the ground. The stability of this mark during the cessation of work is checked by other similar marks, placed in a line perpendicular to the base line. The record is kept in duplicate by

two recorders, also all readings, accompanied by observations of the state of the weather, cloudiness, dampness, etc.

In an apparatus like the above described, composed of so many parts, and liable to change length at each of the places of contact, frequent comparisons with a standard are necessary. The standard used was a fifteen-foot brass bar, the temperature being fixed by packing it in ice which was constantly renewed. To determine what the length of the tubes was during the measurement, the comparisons were made under tents, and under circumstances as nearly the same as those of measurement as possible, and continued from 8 A. M. to 6 P. M., so as to include the same diurnal fluctuations of temperature as took place during measurement.

The method of comparison was as follows: —

Two contact level comparators reading to one hundred thousandth of an inch, were mounted on heavy stone piers, a little more than fifteen feet apart. The masonry supports of these piers rested on rock, and the piers were boxed nearly to their tops, to protect them from unequal changes of temperature. A tube resting on its trestles was placed between the comparators, the standard bar packed in ice was placed on top of the tube, and carefully aligned, and then by motions of the trestles, one or the other was brought between the comparators, contact made, and the comparators read, as well as the thermometers in the tubes. In reducing, the thermometers were corrected for their errors, and the readings on the standard bar and tubes plotted as ordinates with times as abscisses. On inspecting the curves made by the plotting of comparisons of tubes with the bar in ice, when temperature was above 65°, slight depressions are seen in the tube curves, arising from the cooling effect of the ice during the five or ten minutes it was on the tube. In extreme cases, these depressions amounted to .00040 inches.

The values of the comparator screws being very carefully determined, the differences between the tube and bar curve give the corresponding differences in length, and hence the length of the tube from the computed length of the bar at the observed temperature. In computing a measured line, every tube length in the several thousand times each was used, had to have these several following corrections applied: —

1. For inclination of tube to horizontal plane.
2. For reading of contact level.
3. For error in sector level adjustment.
4. For error in cylindrical surface above referred to.

The first of these needs no explanations. The second arises from the fact that the tube is at its definite length when the bubble is at the middle of the contact level, and changes by very minute known quantities when the bubble is not exactly in the middle. The third arises from the fact that the sector level is not stable in adjustment. When found, it is assumed to be proportional to the number of tubes measured since the last adjustment. It gives

a correction both to the grade angle and to the tube length. The fourth arises from a slight defect in the cylindrical surface, by which the tube was slightly shorter at *O* inclination than at any other. The sum of these corrections applied to the sum of tube lengths as found for each day's measurement, gives the length of the base.

To form an idea of the accuracy of the measurement of a base line, a portion of the Kewenaw Base, ninety-four tube lengths (about 1,410 feet), was measured over seven times. Deductions from a table of residuals, giving the excesses of the separate measures over their mean, shows a probable error of one measurement to be in .030 inches, or about 1–560,000.

Now again, besides all the corrections above applied, there are a number of others to be looked into before the length of a line can really be said to be obtained. The alignment of tubes which one would think could not be out an appreciable amount, carefully done as it is with theodolites, showed after numerous trials in testing for a lateral deviation from a right line, that, in the Buffalo Base, for instance, it amounted to .024 inches. There is another error entering into every measurement of a tube length, arising from the pressure of contact between consecutive tubes. This pressure, when reduced to the lowest amount consistent with constantly overcoming the friction of the sliding rod, was still four ounces. A tube, for instance No. 2, when brought into line and forced back against No. 1 till the bubble played, followed No. 1 some. No. 1 was in turn brought back away from it, and it was forced farther back when No. 1 was again placed in front of it. The amount of this disturbance varied with the precision with which the movable parts of the trestle fitted into each other, and with the hight to which the tube is raised by the vertical motion of the trestles. The results, from a hundred determinations of the amount of this displacement when pressure was adjusted to about four ounces, gave a mean of .00034 inches when the trestle was at its maximum hight, and .00013 inches when the trestle was down.

In the Buffalo Base, when the hight of the trestles averaged seven inches, and the line contained 1,483 tubes, the correction amounted to .69 inches. The last correction is to reduce the length as measured, to that of mean ocean tide level at New York. The Buffalo Base, levels of which were taken to and from Lake Erie, distant six miles, by the writer, and with results which happened to differ in the two measurements by less than one-tenth inch, showed it to be 35.7 feet above mean lake level, and mean lake level being 573.6 feet above New York tide, gave the Base an altitude of 609.3feet, making the correction for tide level a reduction of 7.77 inches.

The Buffalo Base Line as measured, with all corrections applied. and with decimal places beyond hundredths stricken out, is given at 266,966.61 inches.

Triangulation, carried over from the Sandy Creek Base at the other end of Lake Ontario, and distant two hundred and ten miles (measured similarly, and a year before), only differs from the above result by 1.44 inches in the computed length of the base line, or a discrepancy of about one in one million.

Now the probable error of an observed angle of average weight in the system, was found to be about one-half a second, which carried through the triangulations, gave results of 65.3 in units of the seventh place of logarithms, as the probable error in the length as computed. Comparing this with the difference actually found between the measured and computed lengths, 1.44 inches, it is seen that the actual discrepancy is about one-third of the probable error derived from uncertainties in the values of the observed angles, and therefore the discrepancy in measurement of the Buffalo Base line is about one in three millions.

WALTER S. RUSSEL.

THE POWER OF WATER MOTORS.

WATER motors are in such common use in cities and towns having water-works, that any information bearing upon their efficiency and power will be of interest to the Society. Perhaps no form of prime mover is so over-rated as the water motor of the Backus and Tuerk types.

A test on a 30-inch Backus motor conducted by the writer last summer in the city of Ann Arbor, will illustrate this point. In the Backus Motor catalogue (see p. 25), the 30-inch Double Motor under a pressure from 75 lbs. to 150 lbs. per square inch, is rated at from 8 to 12 horse-power.

The pressure during the test was about 83 lbs., and the maximum power taken off by the brake was 2.14 H. P., as shown by the following table:—

TEST OF 30-INCH DOUBLE BACKUS MOTOR.

No. of Test.	Radius of brake arm.	Weight of end of arm.	Revolutions per minute.	Brake horse-power.	Remarks.
1.	5¼ ft.	3 lbs.	564	1.692	When radius = 5¼ ft.,
2.	"	4 "	484	1.736	B. H. P. = $\frac{w.r.rpm.}{1000}$.
3.	"	5 "	428	2.14	
4.	"	6 "	352	2.112	

The total horse-power and efficiency are as follows: head = $\frac{83}{0.4888}$ = 192 feet; velocity = $\sqrt{64.4} \times 192$ = 113.2 feet per second.

Area of $\frac{1}{2}$-inch nozzle = 0.1963 sq. ins.
" $\frac{7}{16}$ " " = 0.1503 "
Total " nozzles = 0.3466 " = 0.0024 sq. ft.
Volume flowing per second = $113.2 \times 0.0024 = 0.2717$ cu. ft.
$0.2717 \times 62.4 =$ 16.95 lbs. per second.
Coefficient of discharge = 0.8
Actual calculated discharge = 13.560 lbs. per second.
$\frac{192 \times 13.56}{550}$ = 4.73 total horse-power.
Maximum efficiency = $100\frac{4}{4}\frac{4}{7.8} = 45.2\%$.

The pipe leading to the motor was large, and put in with easy bends, in all respects a good job. The power realized was without doubt the most to be had with the nozzles used, $\frac{1}{2}$ and $\frac{7}{16}$ inches. The speed of wheel for maximum power was about 428 revolutions per minute = 7.13 per second; and $7.13 \times 2.5 \times 3.1416 = 55.97$ feet, or about one-half the velocity of the jet for the best speed of buckets.

It will be seen, therefore, that the claim of the makers of from 8 to 12 H. P. is scarcely realized; further, it will appear that it cannot be realized when the total power, neglecting the coefficient of discharge, is only $\frac{4}{0.78} = 5.9$ H. P.

Although the Tuerk Motor is also over-rated, it is somewhat nearer the truth than the Backus, as will be shown by the following calculation: A No. 12 Tuerk Motor is about the same size as a 30-inch Backus, and is used with a single $\frac{5}{8}$-inch nozzle. For a pressure of 83 lbs. per square inch (see catalogue, p. 11), this motor should give about 5 horse-power at a speed of about 463 revolutions per minute.

Area of $\frac{5}{8}$ nozzle = 0.3068 square inches = 0.00213 square feet, and $213.2 \times 0.00213 = 0.241$ cubic feet per second. $0.241 \times 62.4 = 15.04$ lbs. per second. $0.8 \times 15.04 = 12.032$ lbs. per second, and $\frac{192 \times 12.032}{550} = 4.2$ total horse-powers. If there were no losses, then $\frac{4}{.8}^2 = 5.25$ H. P., which is but $\frac{1}{4}$ H. P. above the power rated in the catalogue. The actual H. P. will be not far from 45 per cent $\times$ 4.2 = 1.89 H. P.

The efficiency of this class of motors rarely exceeds 50 per cent. The *American Engineer*, issue of April 11, 1885, gives results of experiments on a 30-inch Backus and a No. 11 Tuerk Motor, by Mr. A. J. Jones, Superintendent of the Brunswick (N. J.) water-works, from which the following is extracted:—

Backus.					Tuerk.			
Press.	Rev's.	H. P.	Efficiency.	Wt. of water usd.	Rev's.	H. P.	Efficiency.	Wt. of water usd.
			per cent.	lbs.			per cent.	lbs.
50 lbs.	295	0.394	48.33	232.8	363	.552	46.34	341.2
					305	.696	47.32	468.2
45 "	239	.318	46.	220.2	366	.548	48.02	363.1
					274	.26	49.09	168.7
40 "	287	.273	47.14	207.5	378	.36	46.87	274.9
					364	.554	45.74	433.2
35 "	223	.212	44.7	194.1	312	.302	47.05	258.1
					300	.454	44.85	416.5
30 "	208	.159	42.26	180.	340	.323	43.10	358.2

The power realized from these motors is very small in amount, and the efficiencies are nearly all above 45 per cent. The efficiency of the Backus appears higher with the maximum load for which the whole was tested, while that of the Tuerk is higher for some of the smaller loads.

The amount of water used for any one of these motors doing considerable work, is necessarily large. For example: The Backus double motor tested consumed 13.56 lbs. per second = 48,816 lbs. per hour = 5,858 gallons per hour approximately, or 2,735 gallons per H. P. per hour. For 8 H. P., about 21,880 gallons per hour would be required. It would therefore appear that except for very small powers, the water motor in its present form is not likely to be used to any great extent.

Water motors for considerable power, and known as the Hurdy Gurdy, are used on the Pacific slope in the mining districts under the enormous heads existing there under which turbines would soon wear out. With a special form of bucket, known as the Pelton, an efficiency of over 85 per cent is claimed to have been reached.

M. E. Cooley.

COVERING STEAM PIPES.

The benefits of covering steam pipes to prevent radiation, are strikingly illustrated by the following example: —

The Thompson Houston electric light plant in Ann Arbor has about 60 feet of 7-inch pipe connecting the boilers with the engines, and two large steam drums above the boilers. In March, 1887, the steam at the far end of this pipe was tested to determine the amount of entrained water, the pipes and drums at the time being uncovered. An average of nine experiments gave 31.01 per

cent of moisture. In June of the same year, after the pipes were covered with magnesia sectional coverings, the quality of the steam was again tested, the average of five experiments giving 3.61 per cent moisture. The tests were made by the same men, from the same connections, and in the same manner. The pipes and steam drums in March were subjected to a draught, which of course aided the condensation. Enough water passed into the cylinders to retard the engines, producing a disagreeable noise. In June, the weather was warmer, and the pipes and steam drums were well protected. The quality of steam at the boilers was tested in June, and showed about 3 per cent of moisture.

Assuming that 100 I. H. P. were being developed at the time, and that each horse-power required 30 lbs. steam per hour, we would need 3,000 lbs. steam. If the steam is assumed to have 25 per cent entrained water due to condensation in the pipes and connections, then 4,000 lbs. steam will need to be produced in the boilers, or 1,000 lbs. more than necessary. To produce this steam will require about 125 lbs. of good coal per hour, or 1,000 lbs. per day of 8 hours. One-half ton per day, at $3.00 per ton, for 300 days = $450, which at 6 per cent pays the interest on $7,500. The actual cost of the covering put on complete, probably did not exceed $150.

M. E. COOLEY.

THE MICHIGAN CENTRAL TRANSFER STEAMER "ST. IGNACE."

THE problem of making safe and sure winter connection between ports at different points on our great water-way, has always been difficult of solution. Bridges are not advisable, sometimes not possible, and of necessity transfer steamers and passenger ferries must be used. In comparison with paddle boats, propellers have proved themselves the better workers in ice, if there is plenty of water under them. The Michigan Central R. R Co.'s problem then was, Given plenty of water in the straits of Mackinaw, six miles wide, and plenty deep enough, to construct a transfer that shall be trustworthy in all weathers, and to which ice will be no obstruction. The solution was the "St. Ignace."

She was built in 1888 by the Detroit Dry Dock Co., after designs by Mr. F. E. Kirby, a member of this Society. His experience in planning, and the company's experience in building boats for this kind of work, have made her probably the most successful boat of her class ever built.

She has 201 feet length of keel, 232 feet over all. Extreme breadth, 52 feet; molded depth, 24 feet; capacity, 10 freight cars or 8 passenger cars; light draft, 15 feet; load draft, 17 feet; load

displacement, about 2,600 tons. The lines of her forward and after bodies are very much alike, and are finer than is common with boats of this class, fitting her to attain a speed of about 15 miles per hour. Owing to the rounded shape of her cross section, slush ice, the worst enemy of the flat bottomed boats, cannot stick to her bottom, and so retard her progress. The bottom is completely swept by the powerful currents from the propellers.

The hull is of remarkably strong construction, especially the bow, which has to resist the crushing force of great masses of ice. The frames are 24 inches deep on the keel, and 12 inches thick; spaced, 33 inches centers; planking, 6 inches thick. She is plated from the keel to a point above the water line. All above a point below the load water line, is ½-inch steel. The remainder is $\frac{3}{16}$ inch steel. The stern and rudder guard are specially protected by plating three inches thick. It will be noticed that the lower deck beams, 10 inches square, come just at the level of the load water line, where the pressure of ice is greatest. They are spaced 33 inches centers the entire length of the boat, cut, of course, at the hatches. The drawing also shows the breast hooks, three at each end of the boat. They vary from 11 to 13 inches in thickness. Exceptional care was taken in framing the "dead-wood" at each end, making stem and stern almost as substantial as solid timbering. Between the frames and planking, let into the frames, is a system of diagonals of 5 inches by ⅝ inches iron, bolted to the frames, and riveted together at the crossings, which gives great longitudinal stiffness to the boat.

The two tracks are parallel to the side lines of the deck, leaving room for the cabin between them. The cars are run on at the bow, which is only 20 feet wide, and the tracks cross on the table to simplify the curves on the boat. The swinging table is 50 feet long. The rails are laid on pine sleepers which rest on the upper deck beams, and a line of stanchions runs the length of the boat under the middle of each track, except at the boiler hatch. Here the beams are iron, with channel iron stanchions between the boilers.

The crew are quartered below decks in the after part of the boat. The cabin above decks is very complete in plan, differing in this from the ordinary transfer boats, because of the length of her route.

Kitchen and dining room, ladies' saloon, officers' quarters, smoking room, dressing rooms, etc., are provided and nicely furnished. Additional room is secured on the saloon deck by making it project over the lower cabin at the sides, still leaving plenty of room to work on deck around the cars.

She has two fore-and-aft vertical compound engines, the forward one being 26-inch and 48-inch cylinders by 40-inch stroke: after one 38½-inch and 53-inch cylinders by 48-inch stroke. The forward propeller is 10½ feet in diameter and 15½ feet pitch. It is so con-

structed that all its faces are driving faces, hence it is equally efficient whether its engine is working forward or reversed. The after wheel is 12 feet in diameter, and 15½ feet pitch. Both are well below the water line out of reach of the ice, the top of the forward one being nearly 6 feet, and of the after one 4 feet below the surface when she is loaded. The shafts are each about 70 feet long, including crank shafts.

The boilers are three in number, of steel, 11½ x 18 feet, working at 130 pounds' pressure. They are of the double-ended type, combustion chamber in the middle. There are four furnaces, aggregating 91 square feet of grate surface in each boiler, burning all together about 10,000 pounds of coal per hour. They occupy about 34 feet of length in the middle of the boat. They are connected to a single steam drum, from which the steam is distributed to the engines. The steam pipes are of copper, and exhaust pipes to condenser are of wrought iron.

A single condenser is used, located by the side of the after engine. The two air pumps, 24-inch diameter, and 16-inch stroke, work at the ends of a beam operated by special engines, so that either of the main engines may be stopped at will.

The coal bunkers are of 300 tons' capacity, between the boilers and engines. The coal hatches, 4 in number, are between the rails, so that the coal can be taken from hopper cars without handling.

The steamer is steered by a specially designed steering engine situated on the main deck, 27 feet below the pilot house floor. The valve is operated by a hand wheel in the pilot house. There is also a pair of large steering wheels connected directly with the drum on which the ¾-inch wire tiller ropes are wound, for use in case of accident to the engine. The rudder stock is 9 inches in diameter, and as the rudder is protected from the ice by a heavy wing of timber, there is scarcely any possibility of injury to that part of the apparatus. A 6,000 candle-power electric light, operated by a small dynamo in the after engine room, and capable of being turned in any direction by the pilot, is placed on the pilot house.

A valuable feature of the outfit not possessed certainly by any other boat on the lakes, and probably by no other American-built boat, consists of two iron tanks 6 feet square, extending the breadth of the boat on the main deck. They contain from 15 to 20 tons of water each, and act as anti-rolling tanks. When the boat rolls, the water runs to the lower end of the tank, and is just enough behind the roll to meet the boat as she rises, so that it is always found on the rising side of the boat. This principle, applied by Mr. Kirby to a small model, reduced the rolling more than 75 per cent.

There are four steam capstans on the deck for handling the lines quickly and effectively when the boat is at the dock. The engines are close up against the lower side of the beams, out of the way,

and nothing appears above deck but the capstan head, and the handle for opening the steam valve.

To prevent the heavy waves or the ice from coming over the bow, a heavy gate has been constructed, swinging on hinges set on top of the rail of the boat, which rises up to let the cars pass under.

Under the head of "outfit" might be noticed a portable dock which was sent with the boat. It fits either end of the boat well enough to be made water-tight by a loosely spun rope of oakum. In case of damage to a propeller, this dock can be put on, pumped out, and the damage attended to while she is at her wharf.

As the cars, especially long passenger cars, come very close to the cabin when she is loaded, it was thought advisable to provide against the consequences of a sudden lurch of the boat in heavy weather, by putting screw jacks under the corners of the cars to prevent rocking. They are put under all four corners of each car on a very rough passage, but need not be used much in summer.

By her performance, the "St. Ignace" has realized the hopes of her most sanguine friends. Her anti-rolling tanks have been thoroughly tested by using them with all depths of water in them. Full of water, they only increase the roll, bringing it near the danger limit in very rough weather; but used half full, or a little less, the effect is as great as was anticipated from the use of the model referred to. She rolls very slowly, with no quick recoil appreciable.

She has cut her way through field ice two feet thick without great difficulty or any injury to herself, and has not been hindered by ice clinging to her bottom, as before noted. The severest test of her power is applied when she crosses a "windrow" of ice. These windrows are piled up at the leeward edge of a field during a hard blow, and are sometimes twenty feet deep, and consist of loose ice and slush. She has never been stopped by one of them, and from the way she has behaved at these times, it is thought she will meet all the demands upon her in the future.

To come into her slip when it is full of ice, the after engine is worked full speed ahead, while the forward one is reversed. As the after one is twice as powerful as the other, she works slowly ahead, while the forward engine throws into the slip under the ice a powerful current of water that heaves it up and breaks it. Then with both engines full speed ahead, she forges into the slip, and the ice is further ground up and drawn out by the current under the boat.

With such complete success in view, it may be that some day we shall see a fleet of boats, headed by another of the "St. Ignace" type, making the trip from Chicago to Buffalo as regularly in winter as in summer, without a day's stoppage "icebound."

E. L. Mc ALLASTER.

LAKE SUPERIOR MINES.

To the President and Gentlemen of the Michigan Engineering Society: —

THE country bordering the "great unsalted sea" of the North, is one of marvelous mineral resources. That portion of it known as the upper peninsula of Michigan, is an empire within itself. But the blue waters of the lake wash also the far-reaching shores of Wisconsin, Minnesota, and Canada. The stores of valuable mineral, already discovered in all of those sections, excite the wonder of the most casual observer. Indeed, they attract the attention of the whole world. The products of the mines of Lake Superior have found their way to the most distant markets, and, owing to their excellence and purity, are highly appreciated, and eagerly sought after.

During the season of 1888, the iron mines yielded 4,671,947 tons of ore. During the same period, the copper mines shipped 59,574,066 pounds of refined copper, equal to more than 29,000 tons.

Within the memory of many of my hearers, this country was called a howling wilderness — a land of ice and snow — not likely to attract settlers, or become the home of civilization. In 1840, in the United States Senate, the great Henry Clay ridiculed the idea of a ship canal at Sault Ste. Marie, and said that we might as well undertake to open a way to the moon.

When the General Government gave us the Upper Peninsula as a sop to allay our angry feelings in the little boundary dispute down by the Maumee, our people received the gift with a scoff and a sneer. But there was a divinity that shaped the contour of our great State better than all the engineers and surveyors of that day could have done it. It is a trite saying that "we do not always know what is best for us." Surveyors often run random lines, not knowing where they will come out. The random work of Uncle Sam in giving us the Upper Peninsula, *nolens volens*, has placed our Michigan at the forefront in the way of resources.

It is with this portion of our commonwealth — the Upper Peninsula — that I now have to do. Your honorable Secretary intimated that a chapter on the mines of Lake Superior would be acceptable at this time. I gladly assented to his proposal, but would venture to remind you that the subject is a broad one. In the brief time allowed by your rules, I can scarcely do more than outline the subject. I must needs invoke the aid of a 40-horse power air-compressor engine, such as is used at the mines, to help in condensation. Highly rarefied "wind," as I understand it, is not favored by this Society.

So I must skip over the topography and surface geology of the country, and bring you at once down to the mines. All specula-

tions as to the origin of the chief minerals, their abundance, and as to what future discovery may reveal, must be ignored.

The two principal fields, at the present time, are those of iron and copper. It is to the mines in these fields that I would call your attention. There are silver and gold mines of great promise, but those industries are as yet in their infancy. Other valuable minerals are known to exist, but their development lies in the future.

The iron fields are the most extensive. Actual discovery covers a large territory, but much is left to be revealed. Beginning far down the Menominee River, the iron belts sweep through the counties of Menominee, Iron, Marquette, Baraga, Ontonagon, and Agogebic, hundreds of miles, and, overleaping the western boundary of Michigan, pass into Wisconsin, and over into Minnesota on the north side of the Lake, — a grand sweep indeed. The arithmetic of man would fail in estimating the hidden wealth of this vast territory. The iron ore is of the best quality; there are several varieties. The Bessimer and Magnetic ore are the most valuable. The immense deposits of ore, found in individual mines, is wonderful. The hard facts in the case do away with fable. Bodies of pure ore, thousands of feet in length, a hundred feet in width, and of unknown depth, invite the miner's attention, and reward his toil.

The geological surveys under Dr. Houghton afforded a glimmering of the existence of iron in the Upper Peninsula, but it was reserved for Mr. Philo M. Everett, of Jackson, Mich., who organized the Jackson Mining Co., to discover, under the guidance of an old trapper and fisherman, a Frenchman named Louis Nolan, ridges of ore, at a place back of Carp River (now Marquette), near Teal Lake. Professor Shepard, of New Haven, Conn., when shown a specimen of the ore, declared it to be very fine, but thought it nearly worthless, as it was so far away. Numerous successful and very profitable mines of many years' standing attest the value of this discovery, and the two flourishing cities of Negaunee and Ishpeming bear witness to the richness of the ore beds around Teal Lake. If you wish to see industry, enterprise, skill, and prosperity exemplified, visit these thriving mining and pioneer centers.

At first, the shining black or slate-colored iron ore cropped out in long narrow ridges, from 20 to 100 feet above the general surface. The faces of the cliffs were denuded, often polished. They had *weathered* in many places, and masses of the pure ore had rolled down to the bottom. The first mining operations were simple enough, and consisted in quarrying the ore on the surface. But as the work went on, and mining went under ground, new and more scientific methods had to be adopted. Regular shafts were sunk, and underground drifts or galleries were planned. The aid of machinery was called in. Shaft and engine houses were built;

in short, the original quarry became, in time, a great mine, with all modern appliances in equipment and plant. A busy mining town, homes of the miners, operatives, and merchants, grew up close by. Tram car tracks checker the surface, and the locomotive, hauling long trains of ore cars, is busy in every direction. The earth is torn up on all sides; *here* a pile of waste material; *there* a pile of shining ore in the stock pile; and, in the midst, great yawning excavations, whence the iron has been removed, and which you must take care not to approach heedlessly.

The older mines are now down many hundred feet. Heavy hoisting machinery is used in bringing the ore to the surface. Then T-railways lead down into the mine. Tram roads are laid in the underground galleries. Long steel drills, run by compressed air, bore a 2½-inch hole 20 feet deep, speedily into the solid ore. A dynamite cartridge is dropped into it, and the explosion brings down great masses of a hundred tons or so. This is re-broken, loaded into cars, trammed by men to the skip shafts, hoisted to the surface, and dumped on the platform prepared for it. Here it is assorted, loaded on ten-ton cars, and hauled to the Great Lake or elsewhere. Mining for iron is a simpler matter than mining for copper. Still some of the iron mines are of such great width, and the containing rocks are so unstable, that much timber and engineering skill are called into requisition in placing it. Large pumps are necessary to free the mine of water. The mines are well ventilated, the air pure, with no dangerous gases threatening explosions. Care is exercised in the use of high explosives, only the most intelligent and trusty men being allowed to use them.

Great skill, great economy, a liberal use of modern inventions, are seen at these mines. The progress made in mining during the last quarter of a century exceeds all pre-conceived ideas or practice. It is such inventions and appliances that insure the success of mining to-day.

Most of the mining corporations of Lake Superior show great liberality toward their employees, and some of them show a humane spirit which is truly admirable. Churches, hospitals, schools, libraries, places of innocent amusement, comfortable cottages, etc., are provided for the people. I am happy to say that the squalor, poverty, misery, and turbulence that characterize many mining communities do not exist on Lake Superior; and I am inclined to believe that Lake Superior miners, as a class, are "superior" men.

But I can devote no more space to the iron mines. I already stand in fear of the President's bell, lest it ring me down.

We now come to the copper district, which occupies a distinct geological field north of the iron.

By reference to a map of Lake Superior, you will observe a prominent cape jutting far out into the lake. This is known as Keweenaw Point. By reason of the artificial canal, named the

Portage Lake and Lake Superior Ship Canal, this point is now actually an island. The copper-bearing rocks constitute the backbone of this remarkakle cape. The trap range, as this backbone is called, begins at the extreme northeast end of the Point, and runs in a southwesterly direction through Keweenaw, Houghton, and Ontonagon counties, a distance of about 150 miles. The width of the range varies from three to four miles, flanked by sandstone, metamorphic, and old red. It is composed of trappean rocks of different kinds. The whole range is tilted up from 32° to 45°. Originally the beds occupied a horizontal position, and were probably of sedimentary origin. At the advent of the white man, the whole surface was covered with a dense forest, the underbrush being very close. The elevation of the range is from 500 to 1,500 feet above the surface of the lake. Three classes of veins and lodes have been worked, — the true fissure vein, as at the Cliff mine; the contact vein, as at the Minnesota; the amygdaloid belt or lode, as at the Quincy; and the conglomerate lode, as at the Calumet and Hecla. These are characteristic. Fissure veins cross the range at right angles, having a northerly and southerly course, and dipping a few degrees to the east. These veins produce mass copper, as main out-put. The contact vein runs with the formation, and also produces mass copper. The amygdaloid and conglomerate belts or lodes, also run with the formation constituting a part of the solid mass, and while they yield considerable irregular mass copper, their main supply and dependence are found in what is called "stamp copper," that is to say, virgin or native copper in the shape of shot or flakes distributed throughout the matrix of the lode, requiring stamping and washing to fit it for the smelting works. I beg to remark that the Lake Superior copper is not an *ore*, like iron or the sulphuret of copper, but a virgin metal, like gold. Copper ore, it is true, is found at some points on the range, but its exploitation has never, thus far, been attended with success.

The existence of copper in that country was known to the aborigines and to the *voyageurs* and Jesuits. An English company, under Henry, in the last century, undertook mining in that region, but failed. The astute Ben. Franklin was informed on the subject. As one of the commissioners to settle the boundary line between the United States and British Possessions, he carelessly drew a red line through Lake Superior so as to include Isle Royale, which lies within eighteen miles of the Canadian shore, and which, he *guessed* was rich in copper. He was a Yankee, and guessed right.

But long before the Jesuit fathers, with indomitable courage, launched their canoes upon the limpid waters of the lake, an unknown people, named the Ancient Miners, had discovered the copper, and mined for it extensively, though crudely, all through the copper district, including Isle Royale. They were a brave, enterprising people certainly, and their extensive works excite the

wonder and admiration of the modern explorer. They mined with stone hammers and fire.

Dr. Houghton's researches from 1840–45 threw great light on the copper region, and fixed as a certainty the existence of copper in workable veins. The emigration to the new El Dorado rapidly followed his disclosures. Mining was begun, and has continued, under varying circumstances, until the present time. It is now a great and prosperous industry.

Exploring for copper was and is laborious work, owing to the dense forests and deep drift. The drift is anywhere from one to 100 feet deep; at only a few points are the rocks *in situ*, denuded. The discovery of veins and lodes, therefore, is preceded by much digging and trenching, uncertainty and cost.

Modern mining in the copper districts of Lake Superior affords an example of the highest skill, combined with liberal expenditure, indefatigable labor, and profitable results. The road to this high eminence has been long and weary, under losses and discouragements, leaving many wrecks by the way.

Having discovered a lode or vein of promise, we proceed to open a mine. The spot is in the heart of the forest. By ax and brand it must be cleared. Log huts for shelter are erected. Rude engine and shaft houses, carpenter and smith shops, are thrown together with little order. Roads are cut out to the nearest navigable water, in order that supplies and machinery may be brought in. At first the work is tentative. Until the lode has been proved valuable beyond reasonable doubt, expenditures are wisely limited; but the opening of the vein is pushed vigorously. The hunt for copper in quantity is the absorbing business.

But when, after practical experiment — actual work down in the solid crust — the miner feels assured that he has a good mine under his feet, he goes ahead boldly. The engineer lays out the surface ground carefully, locating the working shafts, engine houses, machine shops, rock houses, railways, and town site with care, having in view the future needs of a great mine. The wilderness rapidly disappears, and a bustling mining town, embracing within its limits churches, school-houses, hospitals, stores, miner's cottages, fine mansions, etc., springs up as if by magic. There are hotels without a bar; saloons are *tabooed* on the mine location.

Meantime, the work of sinking shafts, opening drifts, in short, the development of the mine, is pushed day and night. The mining engineer keeps this work well in hand. He establishes a permanent base line on the surface. From this base he carries his triangulations and measurements down the shafts to the underground city. He follows hard after the miner and plats the work on paper at every important step. His fixed points or benches underground are plugs secured in the solid rock. The light of a candle is his guide in the dark recesses of the mine. The working shafts are placed from 400 to 600 feet apart on the line of the lode.

They generally follow the pitch or inclination of the lode in their downward course. At the depth of 100 feet, the first grand level is reached. At this point horizontal drifts are started right and left from the shaft, on the line of the lode. The work in the shaft is ever downward; there is no pause until the second level is reached, and so on to the third and fourth, etc. Between the shafts, below the first level, sub-shafts are sunk to aid in work and ventilation; these are technically called *winzes*. Thus a plan of a well-opened mine resembles a map of a city. The shafts and drifts are the avenues and streets, while the winzes are alleys. The engineer's extended map of the mine, kept in his office, enables him to point out at any time the depth and length of the workings, the position of the pumps, man engine, tram-ways, stopes, rich and poor ground, and the very places where the miners are at work at a certain time.

The mine thus opened, the main work of producing copper begins. The squares in the underground city are mined out from between the walls of the lode. Be the lode five or fifty feet wide, the vein matter, carrying copper, is all blasted down, and hoisted to the surface. This work is called *stoping*. Great chambers are left after the rock is removed. The mine would close up, by the hanging walls' falling down upon the foot, if not prevented by artificial supports, called *stolls*. The heaviest timber to be found in the native forests, — pine and hemlock, — is used for this purpose. They are set up as thick as they can stand all along the drifts. An enormous amount is used monthly. The supply in the yards would cause a stranger to look around for a saw-mill, as a necessary adjunct. Much other timber, called *lagging*, is used under ground to cover the stolls, and for staging. The stolls are so placed that the tram-ways run under them, and the lagging thrown over the stolls prevents the mined rock from impeding the passages, and hurting the men. As the mine is worked out, the upper levels are great unused chasms, but all the timber is left standing. In time this timber becomes very dry. If set on fire, the burning is rapid and fierce, for the shafts are like great chimnies, with excellent draught. The great and disastrous fires which have occurred in the Calumet and Hecla mine within the last two years, afford an example of the danger always threatening a mine of this kind.

Tram roads are laid in each level, and cars pushed by men transport the rock to the hoisting shafts.

The shafts are elaborate and costly. They vary in dimensions, according to the use they are put to. They are solidly timbered and planked from top to bottom, with T-rail tracks laid in them. The track is a steep inclined plane. Cars carrying from four to six tons of rock move up and down with great velocity. These cars, or skips, are made of boiler iron of peculiar shape. Some of the mines are more than 4,000 feet deep. Heavy wire or

steel rope, winding around an immense drum moved by the great engine on the surface, is used in hoisting. The drum is thirty feet in diameter, with friction gear, and one man standing at a little wheel, manages it as easily as a toy. Ingenious indicators, placed before the man, tell him exactly where the car is at any time in the shaft. The skip car is carried thirty or forty feet above the surface of the ground, in the shaft house, where it dumps its load automatically, and immediately descends into the mine.

Surface cars receive the rock, and by means of an endless rope, they are whirled rapidly away to the distant rock house. No man is seen about the shaft house. The cars move automatically, dump themselves, and return to the shaft for another load. Signal bells, under ground and along the surface tram-ways, transmit orders.

The winding engines, moving four thirty-foot drams, are immense in size, but move very quietly, though powerfully.

The pumping-engine is a marvel in its way for power and in construction.

The man engine, used by the miners on their way in and out of the mine, is an ingenious contrivance. It consists of two parallel rods of wood, a foot square, placed about two feet apart in a separate shaft. Every ten feet, on each rod, a narrow platform is placed with an iron hand-railing. In moving, one rod goes down and the other up, with a ten-foot stroke. A miner steps onto one platform, and goes down ten feet. Then he steps across to the opposite platform (which has come up to meet him), and sinks gently down ten feet, and so on, till the bottom of the mine is reached. A hundred men may be on the rods at the same time. All are conveyed rapidly, without fatigue or confusion, to their destinations. There are ladder ways leading down into the mines, but they are not much used. Climbing them is very hard work.

The rock house above alluded to is a great building where the copper rock is dumped, assorted, re-broken, and prepared for the stamp mill. Large blocks of rock, tied together with copper, very tough, are dragged by a chain and steam-power under a great hammer moved also by steam. This hammer or punch is a long solid shaft, standing upright, with a steel pointed end. It drops upon the hard copper rock. and pierces and shatters it like glass.

The broken masses are then conveyed to different sized rock breakers, where they are crunched up into pieces suitable for the stamp mill. From the breakers, the rock falls into great bins; thence it is drawn into rock cars, and drawn by locomotives several miles to the stamps. At the stamp mills this rock is dumped into great bins located near the top of the mill. The rock runs down to the stamp (its motion regulated by one man), where it is crushed to fine sand under a blow of more than forty tons from the steam hammer. A stream of water, pumped up to the top of the building, runs constantly into the stamp mortar, and carries away the sand, slime, and copper to a series of washers moved by machinery.

The jigging movement of the washers causes the copper to settle onto the wire screens, while the water carries the sand and slime away to a place of deposit.

Immense pumping machinery is used. A large volume of water is, in some cases, elevated 100 feet, and distributed. Each stamp has a capacity of crushing from 100 to 150 tons of hard rock, during each twenty-four hours. The Calumet and Hecla mine has sixteen to twenty of these stamps, and can stamp at least 1,600 tons per day.

The limit of my article will not permit me to make more than this brief mention of the great stamp mills in the copper districts.

Most of the mines have fully equipped steam freight railroads of their own, which are kept constantly busy.

Large smelting works for reducing and putting the copper in shape for market, are appendages of the mines. There are likewise rolling mills of great capacity, wherein sheet copper, wire copper, etc., are made and shipped.

The old-fashioned way of mining with hand drills and black powder, is now obsolete. Power drills, run with compressed air, do the boring in the solid, copper-fastened rock. Dynamite cartridges do the rending and tearing very effectually. These improved methods have greatly reduced the cost of mining, and facilitated the work underground. Nay, they have been the salvation of many mines, during eras of low-priced copper. Each drill does the work of ten men, thus saving the cost of that many miners for each. Work is also done much more rapidly. For example, with powder and the hand drill, two levels only could be sunk in a year. With the power drill and dynamite, one level a month, or twelve in a year, can be sunk. The same proportion holds with drifting, stoping, and other kinds of work.

The diamond drill is much used for exploring purposes, either in sinking from the surface into the earth's crust, or in the mine.

The Calumet conglomerate charged with copper, is well defined and unmistakable. It lies inclosed between trappean rocks of entirely different structure and character. For these reasons, the miners have no difficulty in following the lode.

But in amygdaloid belts, the courses of copper are more irregular and uncertain. The lode proper is sometimes lost, or becomes mixed up with the *country*, or containing rocks. The copper has somehow disappeared. The diamond drill now comes in as an efficient agent. Horizontal holes, one inch in diameter, are bored from a selected level, right and left, and the lost lode is found. Perhaps entirely new and unexpected copper deposits are found to reward the explorer. The diamond drill penetrates twenty to thirty feet per day, at light expense. By the old-fashioned way of *cross-cutting*, six miners often spent a month or six weeks in reaching the same result.

Some bold and neat engineering feats have been achieved at the copper mines. At the Tamarack mine, we have a notable example. This company owned two forty-acre tracts of land, situated some 3,300 feet west of the Calumet lode. The Calumet lode was supposed, in its deeper reaches, to dip under this land. But the great problem to be solved was this: If it *does* dip thus far, does it carry copper as rich as that in the Calumet mine? does it carry copper at all? The Tamarack Co. boldly determined to solve the riddle. They sank, in about two years, and at great expense, a huge shaft, large enough for double skip tracks and the pump, over 2,300 feet perpendicularly through the barren trap rock of the country. They struck the Calumet conglomerate about where they expected to, and "*struck it rich.*" It is now the second best copper mine on Lake Superior. The Tamarack mine offers the only example of a perpendicular shaft in the stamp copper mines.

The rapidity with which the shaft was sunk, as compared with old-time mining, was truly marvelous. Boldness, skill, energy, capital, dynamite, and power drills were the important factors in this great work.

I have mentioned incidentally some of the duties of engineers and surveyors at the mines. Every large mine has its engineer and assistants. They are salaried men, and hold honorable, responsible positions. Their duties are various, but not exacting. Many of them are practical chemists and geologists. As civil engineers, they build railroads, and keep them in repair; locate stamp mills, pumping machinery, engine, shaft, and rock houses; and, in short, they look after the *mine plant.* Under ground they have various important duties.

The best hoisting, transit, and drilling instruments are used by them. Great exactness is required. The magnetic needle cannot be depended on in their work. The rocks are so full of iron as to render a common compass untrustworthy. The local variation or deflection is often 20° to 30° in one-half mile. In the woods, the best surveyors have been led astray by the compass, so as to become absolutely lost.

In the iron mines the dip needle has been a useful instrument in the search for hidden lodes or beds. In explorations for copper, this instrument has not been of practical importance.

In engineering, all important work is carried on by triangulation from a base and determined true meridian.

The timbering in mines, where, as the miners say, the ground is "*balky,*" is a matter of first importance. The engineer and timberman are called upon to exercise skill and courage. The hanging wall, after the vein matter has been removed, is a great overhanging cliff. If the ground is seamy or shattered, great masses fall. Good timbering prevents this, but in some fissure veins, the best timbering serves only a temporary purpose. The

dynamic forces at work in the earth's crust, sooner or later close up the openings. The largest timbers are as reeds. The slow, imperceptible, but mighty movements of the rocks, "broom up" the ends of the big stolls, and reduce them to pulp, between the closing jaws of the walls.

In the heart of the mines, at Houghton, a miningl school has been established by the State. A very handsome bu iding of red sandstone, found at Portage Entry, ten miles distant, has been erected on the sightly shores of Portage Lake. Under an able corps of instructors, this institution is doing a grand work. The students are taught higher mathematics, chemistry, mineralogy, geology, and civil, mining, and mechanical engineering. These studies are supplemented by actual work or observation in the field, mine, smelting works, rolling mills, stamping mills, and engine and machine shops. The advantages afforded for practical observation and application are unexampled in this country.

JOHN H. FORSTER.

MANIPULATION OF IRON AND STEEL, AND SIMPLE FORGE-SHOP TESTS.

TESTING of iron and steel in the forge-shop by engineers is of much more importance, and ought to have more attention, than it usually receives. I have talked with quite a number of engineers and architects who said they could not tell good iron from poor iron, and relied almost entirely upon the brand, which is all right in some cases, but will not answer in others. An iron may be very good for one thing, and very poor for another, which makes it necessary to determine whether the iron is fitted for the work in question.

In this brief paper, I will give a few important tests that can be made in the forge-shop. These tests should really accompany those made on the testing machine.

First, it may help us to understand the working of iron if we know its nature, and how it is produced. I must say I consider this important. Only a short time ago I was talking with a gentleman in Detroit, who said he had trouble with working his iron, and could not account for it. I found he had been working it wrong.

Now I will give a hasty outline of the production and nature of iron alloys, for that is what commercial iron is.

Chemically pure iron exists only as a laboratory specimen, and would be of little use on account of its softness and tendency to rust.

Some of the elements improve the quality of the iron, under certain conditions and for certain purposes; as, for instance, carbon in the graphite state makes pig iron, and in the combined state,

makes chilled iron and steel. Other elements, as sulphur and phosphorus, injure iron, and render it poor for almost any purpose. Iron or its alloys is divided into three great classes, and these again subdivided into many more. I will give them in the order in which they have come into use: (1.) Wrought Iron; (2.) Steel; (3.) Cast Iron.

The first two of these have been known and worked from the beginning of history, but the last one is of recent date; and I think we may look for other alloys in practical use before many years.

Wrought iron was produced from very rich ores piled in with great quantities of charcoal in a pot-shaped hole in the ground, and blown by some crude, artificial means. The air was directed on the melted metal somewhat, and the metal was kept stirred with a rod. This decarbonizes it, and leaves a pasty mass instead of a liquid. This mass is called a "bloom," and was drawn out under the hand hammer and thoroughly welded together; this squeezes the slag out of it as well. Charcoal was the only fuel for centuries, and is the best to-day, but cannot be obtained in sufficient quantities to supply the market. About 1600 A. D., pit-coal began to be used, and in 1700, coke. Since then, the iron industry has developed into enormous proportions, aided by the steam-hammer and the steam-engine. Later on the *direct* process of making wrought iron was invented. The product of this furnace is called a bloom, the same as in the primitive furnace, but the blooms are drawn out under the steam hammer, and not by hand. *I wish to call your attention to the blooms as they are taken from the furnace, as this will help us in understanding wrought iron.* The blooms are fibrous and stringy. Perhaps an illustration may make it more clear. If we should take a large number of small rods, bent in all sorts of shapes and tangled together, put them into a furnace, and heat to a welding heat, with a little sand thrown on them, we would have a very good bloom. The fibers or rods lie in every direction; and if we pound the mass into a plate or slab, the fibers lie in one plane. Then the plates are cut, re-heated, welded, and hammered on four sides. This makes shear iron; if the process is repeated, it makes double shear iron. These irons are used in the merchant bar. This kind of iron is tough and fibrous in the direction of its length, if well puddled and welded. But if not well worked, it is apt to be seamy, and crack easily. The shearing and re-shearing up to the sixth time improves the iron. Then it ceases to be of value, and becomes injurious. This process is rarely ever repeated more than twice. In 1856 the Bessemer process of making wrought iron and steel was invented, by which the iron was decarbonized by forcing a large number of small streams of air through it. This freed the iron from carbon and most of the other impurities, and then the iron was cast into ingots. These ingots are very homogeneous and ductile. When cast, they are not fibrous, but seem to be a mass of globules or grains held firmly to-

gether. When the ingot is rolled, these globules seem to elongate, and to resemble fibers to some extent. This kind of iron is stronger and more ductile than bloom iron, and is also free from flaws.

Steel, the next alloy of iron, dates back almost as far as wrought iron, and was made in the same primitive furnace by leaving enough of the carbon in the iron to make it harden and temper. This steel might, under very favorable circumstances, be quite good; but generally it was poor, unreliable, and full of flaws. Mild steel, and even some grades of high steel, are produced in the Bessemer converta by first decarbonizing cast iron, then adding just enough carbon to make the quality of steel required, and then casting into ingots, and rolling into the required shape. This steel is malleable, and can be welded when it contains less than one per cent of carbon. Tool shear-steel is made by heating very fine grades of wrought iron in a furnace with layers of charcoal, and keeping at a red heat for from ten to fifteen days. This is called the cementation process. Crucible steel is made from cemented steel by melting in a crucible, casting into ingots, and drawing out into bars. This steel is very homogeneous, and will harden to a great degree. Crucible steel can be made by melting small pieces of fine iron in a crucible with charcoal. This steel has been made for about 200 years, and has from 81 hundredths of one per cent to one and one-quarter per cent of carbon.

Cast iron is a direct product of the ore when it is melted and drawn off without being decarbonized. Strange as it may seem, it appears to have been put to but little use till within about 300 years. The art of making large castings, and the use of the cupulo furnace, belong to the work of the last 120 years. Cast iron does not properly belong in this paper, and I will drop it here.

Testing of wrought iron and steel in the forge shop, to determine whether the metal in question is good, bad, or fitted to its use, is a very interesting piece of work. Usually the testing machine would do some of this work better, and will of course do work that cannot be done in the shop; but on the other hand, the forge shows things that the testing machine will not.

HEATS.

There are four principal heats, as follows: First, low red or cherry heat, where the iron just turns red; second, red heat; third, white heat; fourth, welding or sparkling heat, where the iron begins to fuse; but as soon as the iron looks greasy, it should be removed from the fire, as the high heat oxidizes the iron, or burns it away.

FLUXES.

The fluxes used in welding are quartz sand for wrought iron and low steel. The silicon unites with the oxide of iron, and

forms the silicate of iron, which is a slag. This forms a greasy coating over the iron, and protects it from further oxidation.

When the iron has reached the welding heat, the two pieces to be welded are brought together and the blow struck, the slag squeezes out, and the bright iron unites. Borax is perhaps a rather better flux. I find a large number of blacksmiths who do not know what they use borax or sand for, but seem to have an idea that it acts as a sort of cement to stick the iron together, whereas if they knew the real use of the flux, they would use less of it on clean iron than on rusty. An excess of flux, and consequently of slag, is objectionable. Borax should be used for most steels containing less than 75 hundredths of one per cent of carbon. It fluxes better, and forms a thinner coating on the iron. The borax should be first heated to expel the water, as it contains a large amount of it. When it is required to weld steel of a high grade, the flux used should be one part of sal ammoniac and sixteen parts of borax. The sal ammoniac cleans the steel a little better, so it is well to use a small amount of it with borax. High grades of steel must be worked at a low white heat, as the carbon at a high heat has an affinity for oxygen, and will leave the steel. High steel will weld at a much lower heat than wrought iron, as the carbon helps to flux the iron at a low temperature.

HARDENING.

Wrought iron will not harden at any heat when plunged in water. But poor wrought iron containing some carbon will harden in spots. Steel with less than 15 hundredths of one per cent of carbon will soften when plunged into water of less than 60° F. But all grades of steel with more than 15 hundredths of one per cent of carbon will harden in water at 60° F. The proper heat for hardening is from cherry red to red. Cast iron will chill when heated and plunged into cold water.

HARDENING FLUIDS.

When it is required to harden steel, we have to use some substance that will remove the heat quickly; the quicker, the harder the steel. Some form of liquid is generally used. For a moderate degree of hardness, used tallow. For a little harder, use lard oil at 60° F.; next, water at 60° F.; next, salt and water very cold; and for very hard, use mercury. This will make the steel hard enough to cut most substances except the diamond. All of the hard steels are very brittle.

TEMPERING.

Tempering is the process of reducing hardness. All ordinary steels when hardened are capable of having the hardness reduced by heat. The heat required to draw the temper is quite low, about

400° to 500° F. Cast iron will harden, as we have seen, but will not temper much. When it is required to temper a piece of hardened steel, the surface is first made bright; then heat is applied; at first a yellowish white or bright straw appears, then a dark straw, golden color, brown, purple, violet, and deep blue. These colors form what is known as the tempering scale. All degrees of hardness come between the two extremes. The details of hardening and tempering would make a long paper. There is one steel on the market which will not temper; that is, Mushitt's, an alloy of tungsten and iron. This steel is very tough. The Damascus steel was probably of this alloy, quite easily made and of good quality; but some are inclined to think that this steel owes as much to poetry and literature for its reputation as to its actual merits.

ANNEALING.

When steel has been hardened, it can be softened again by heating to cherry red, and allowing to cool very slowly, the slower, the softer the steel. This is the reverse of hardening. Chilled cast iron or hard wrought iron can be softened in this way.

MALLEABLE QUALITIES.

Good wrought iron or steel when heated to a cherry red heat can be drawn out to a point without cracking, or can be flattened as thin as tin plate without showing flaws. Cast iron has no malleable qualities, but malleable cast iron can be worked to quite an extent. Good wrought iron can be worked up to the welding heat without injury, but steel of a low grade should not be worked above white heat, and steel of a high grade, at a red heat. Poor wrought iron and poor steel when heated to a red heat and drawn to a point, will crack. It will not stand working into any shape to any extent.

Iron or mild steel may be considered fairly good for forge work, if it will extend one and one-half to two times its original width at cherry heat without cracking. But high grade steel and tool steel will not stand working at a high heat. The high steel should show no signs of cracking at cherry heat, when drawn out to any extent. Poor wrought iron will draw into most shapes at the white heat, unless it is hot-short.

SHORTNESS.

Iron is cold-short if it is brittle when cold. This kind of iron is very poor for any purpose. Red-short iron is brittle at the red heat. Hot-short iron is brittle at the white heat. This last kind of iron may be quite stiff and tough when cold, and is a good iron for some places. Steels are all more or less hot-short.

TO TEST THE QUALITY OF TOOL STEEL.

Take a piece of tool steel, heat to a red heat, draw into a cold chisel of about 30°, grind to an edge of 60°, harden at a cherry-red heat in lard oil at 60° F. Draw the temper down to a purple color. This chisel, when finished, should cut bar iron and annealed steel, cold, without cracking or chipping, if the steel is good. Low steel or wrought iron will not do this. A very good way of finding out at what heat a piece of steel will harden is to take a bar one-half by three-fourths of an inch, and make nicks an inch apart for about eight inches, and place in the fire so the first piece will get white hot and the last barely red. As soon as it is heated, plunge in water at 60° F., then break the bar up at the notches. No. 1 will be very hard and brittle, while No. 8 will be soft. This is Miller and Metcalf's way of testing and examining the fracture. And right here I want to say that Crescent steel, made by Miller & Metcalf, of Pittsburg, is the best I ever used. But ordinarily, mechanics will get a better idea if they should take each one of the pieces, and grind the end to the shape of a lathe tool, and try the cutting qualities in the lathe. The piece that cuts the best for the longest time, will show what temper to use. The pieces could be tested by grinding into cold chisels just as well.

WELDING QUALITIES.

Good wrought iron, and most of the poorer qualities, except iron containing copper, sulphur, and phosphorus, will weld at the welding heat by the use of fluxes. They will look greasy at the high heat. The more fibrous the iron, the better it welds. To test the weld, bend the bar at any place around round iron until it breaks, then bend the weld over the same bar through an equal distance. If this weld holds, it is very good.

Steel, unless very low, will not weld at the high heat on account of cracking. Steel containing more than one and one-fourth per cent of carbon will hardly weld. It, however, can be welded at the white heat with care by using the proper fluxes. It will not do to heat the steel to the welding heat, as the carbon at this heat has too much affinity for oxygen, and will leave the steel. The carbon, however, helps to flux the steel at a lower heat.

Wrought iron which does not weld well is unfit for forge work. But some of the poorer grades may be very good, if they are not to be welded, where stiff iron is required.

UPSETTING.

Good wrought iron and steel should stand upsetting, at a red heat, to one-third of its original length, without cracking. The test pieces should be short. Poor wrought iron will not do this, except at the high heat, and some of it not then. Iron would not

be considered very poor if it would upset to two-thirds of its original length.

Mild steel, if good, will upset to almost any extent. But tool steel should never be upset where it has to stand shocks. It will, however, stand upsetting a large amount without cracking.

HOT BENDING.

Good wrought iron should bend at the white heat around a sharp corner double without cracking. A fairly good iron should bend around its own diameter. Poor iron will not do this. Steel of all grades should bend around a square corner double.

These tests are in the direction of the fibers. Good iron and steel should bend about as much across the fiber as lengthwise. Poorer iron, if fairly good, should bend about one-quarter as much across the grain.

COLD TESTS. — MALLEABLE QUALITIES.

Very good soft wrought iron and very low steel should stand drawing out about one-tenth of its original length without cracking. Ordinary iron will not stand drawing cold. If an iron cracks and breaks easily when cold, it should not be used.

BENDING.

Very good soft iron up to one inch in diameter and one inch thick, should stand bending double without cracking. No iron should be used for intricate forging which will not bend on these diameters up to two inches in diameter.

Construction iron, according to Thurston, should bend cold, as shown by the following table: —

Inches.	Bar Iron.		Bolt Iron.		Cast Iron.	
	Longest inclined.	Transverse.	Longest inclined.	Transverse.	Longest inclined.	Transverse.
.24						
.24 to .28	50″	30″	80″	50″	110″	90″
.32 " .36	45	25	70	40	100	80
.40 " .44	40	20	60	35	90	70
.48 " .52	35	15	50	30	80	60
.56 " .60	30	12	40	25	75	50
.64 " .68	25	10	35	20	70	40
.72 " .76	20	8	30	15	65	35
.80 " .84	15	5	25	10	60	30

Good iron should stand bending across the grain about half as many degrees as with the grain; fairly good, one-third as many

degrees. Very poor iron will stand bending but very little across the grain.

When a bar three-fourths of an inch in diameter, with a thread cut on it, is bent cold, it should show a crack of less than one-eighth of an inch.

When the machinest cuts the thread on a bar and it crumbles off and shows a large number of small seams, it should not be used without testing in the forge shop.

FRACTURE.

A bar of very good iron, when broken, will show a tough, fibrous structure, free from flaws, and of a dark leaden color. It should show no crystals. Poorer iron may show some seams and little spots of crystals, but the fibers should be tough and of a leaden color. Iron for bridge work should be as free from crystals as possible, and should not be strained beyond a certain limit, as the constant strain and jar tend to crystallization. The oftener the jar, the less the strain should be. Low steel, when broken, should show some fiber and a close grain with a bright luster. Tool steel should have a very fine grain, and a higher luster.

COLD HAMMERING.

This should be avoided, as the best iron, when hammered cold too much, will become crystallized and brittle.

C. G. TAYLOR.

PRACTICAL NOTES ON RAILWAY LOCATION AND CONSTRUCTION.

IN attempting to comply with the request of our worthy Secretary to contribute a paper to be read at this meeting, it has occurred to the writer that a brief account of the work upon which he himself has been engaged for the past two years, together with such comments as his experience may from time to time have suggested, might possibly be of some interest to at least the younger members of the Society. He does not expect to present a single idea that can be called original, nor does he claim that the methods which he adopted were in all cases the best. He only proposes to offer for your consideration an example of engineering construction which has been proved by actual use to be safe, ecomomical, and successful, the most important qualifications to be sought for in all engineering works.

The Chicago, St. Louis & Paducah Railway, of the location and construction of which the writer had charge as Chief Engineer,

extends from Marion, Illinois, to Brooklyn, a small village on the north bank of the Ohio River about three miles below Paducah, Kentucky. It was intended as an extension of what is known as the Cairo Short Line System, and this circumstance limited in some degree the choice of plans for structures to such as would conform as nearly as practicable to the standards which were in use on the old road.

The entire length of the road is fifty-three miles, of which the first ten on the north end are over a rolling country presenting no special difficulties either in location or construction. The next section of five miles crosses the divide between Saline and Sugar creeks, and includes several heavy cuts and some rock-work. Then comes the most rugged and difficult section of Illinois, the crossing of the Ozark Range, a high, rocky ridge, which extends entirely across the State, and therefore could not be turned.

Its summit has a very uniform elevation of about 440 feet above low water in the Ohio River, and presents but few passes favorable for a railroad line. It is composed almost entirely of sand rock of every variety of hardness, and its slopes, deeply cleft by long, rugged, and precipitous ravines, and clothed with dense forests, which often confined the view to the limits of a few rods, fall off so abruptly in both directions, especially to the south, as to present very great difficulties in the way of the economical construction of the road.

From the southern foot of this range the line runs for several miles in a valley shut in on both sides by lofty spurs which shoot out from the main range. It then passes a divide into the immediate valley of the Ohio River, which presents no serious obstacle except the deep gorges cut by the tributary streams, and calling for some of the most expensive structures on the road.

Most of the difficulties of location were met with on about six miles of the Ozark Division, owing to the abrupt descent of the streams, which was more than 200 feet in a mile, and the rugged character of the slopes, which made a surface line entirely impracticable. The best general route was determined by means of preliminary lines run through every gap which appeared at all practicable, but the limits of this paper will not permit any account of the methods employed.

After this had been accomplished, the first important point to be determined was the gradient to be adopted. On the other divisions of the road a maximum gradient of one per cent had been found practicable, and our preliminary surveys showed that by developing the line to a length of about eleven and one-half miles by means of long loops and horseshoe curves, this same gradient could be carried over the ridge. This, however, would have involved an expense which the financial condition of the company would not warrant, and it was determined to build the road on a temporary line, which would answer perhaps for years, until its

business should develop to such an extent as to require something better. For this temporary line the gradient adopted was 1¾ per cent, or 99 feet per mile, and for the following reason: —

Supposing an engine to be pulling its maximum load for a one per cent grade, as would ordinarily be the case with a freight locomotive, it would be obliged, on arriving at the foot of the ridge, either to divide its load and make two or more trips to the top, or employ one or more pusher engines to help it up. It was not desirable, nor did the character of the country require, that *more than one* pusher should be employed, and the choice was therefore confined to a gradient up which two engines could take all, or one engine one-half, of the maximum load. According to the "Tables of Maximum Loads for Locomotives," given in "Wellington's Economical Theory of Railway Location," which are the most convenient and reliable that we have, this would call for a gradient of 2.06 to 2.16 in 100, according to the style of engine used, and, as a general rule, nothing would be gained in economy of operation by adopting any flatter gradient than this, as this would not affect the maximum load on other portions of the road. It was found, however, that a gradient of 1.875 in 100 could be fitted to the ground without any additional cost for construction, and it was therefore adopted for the sake of the small saving in resistance in bad weather.

This maximum gradient was used only on tangents. On the curves, which constituted more than fifty per cent of the Ozark Division, it was reduced at the rate of 0.05 for each degree of curvature. Thus on a 7° curve, the gradient would be $1.875 - (0.05 \times 7) = 1.525$ in 100. From the slight opportunities for observation which the writer has had since the completion of the road, he is inclined to think that possibly this reduction is slightly more than is necessary, and that on a curve compensated to this extent, a train will run a little more easily than on the corresponding tangent. The error, however, if any, was on the safe side.

I mention this matter for the purpose of calling the attention of my younger brethren of the profession to the fact that this practice of reducing gradients to compensate for curvature, though of comparatively recent origin, is now being very generally adopted among the best engineers, and that if they desire to keep up with the procession, they must follow the example.

The rugged character of the Ozark Division required a large amount of sharp curvature, 10° being the sharpest admitted, while 6°, 7°, and 8° curves were numerous. These curves were all flattened at their extremities, the method pursued being that given by Trautwine in his work on "Curves." This method is not very scientific, but practically it answers a very good purpose, and was adopted partly on account of its simplicity, but especially for the reason that it need not be applied until the cross-section stakes are to be set, and the locating engineer, who

has enough head work to do as it is, can make his calculations, and run his lines without taking any account whatever of the flattening of the curves.

While on the subject of field calculations, it may not be amiss to call the attention of the younger members of the Society to a formula which the writer has found of very great value in his field work, and which might be of equal value to them. He learned it from Prof. W. M. Gillespie of Union College, more than thirty years ago, but has never seen it in any published field book, and has reason to believe that few engineers are familiar with it, or at least with the numerous uses that can be made of it. It expresses the divergence of a curve from its tangent, and takes the form —

$$x = \tfrac{1}{8}\, n^2\, D,$$

in which X is the offset or distance of one end of a curve from a tangent passing through the other end, D is the degree of curvature, and N the length of the curve in chords of 100 feet each. Thus a 6° curve will have diverged from its tangent at the end of 500 feet, $\frac{1}{8} \times 5^2 \times 6 = 131\frac{1}{4}$ feet. By making D equal the difference of the degree of curvature of two curves of different radii but having a common origin, X will be their divergence from each other at the end of N stations. This formula is not mathematically exact, and therefore gives only approximate results; but it is sufficiently correct practically for all ordinary cases. It is easily remembered; it requires no tables; and with its aid, with such modifications as a little ingenuity will suggest, and a table of actual tangents for a 1° curve, the locating engineer can solve almost any case that will ordinarily arise in the field. For example: Suppose a 5° curve to the right 8 stations long has been located, and its extremity falls 28 feet too far to the right to throw the tangent on the best ground. Making $x = 28$, we obtain $d = \frac{1}{2}$, showing that a 4° 30′ curve starting from the same origin would pass through the required spot. Again: Suppose that in this same case the new curve is to commence 200 feet back of the first one; then the required divergence from the tangent will be $\frac{1}{8} \times 8^2 \times 5 - 28 = 252$. Substituting this value for x, and making $n = 5 \times 2$, we have $d = 2.88 = 2° 53'$.

This formula will also solve several problems in track laying. For instance, making x = gauge of track, and d = the degree of curvature of a turnout track, or corresponding to a given number of frog, n will be the lead of the main frog. With $x = \frac{1}{2}$ gauge, n = lead of crotch frog, and with x = throw of a stub switch, n will be the free length of the switch rail. Other instances might be given of the uses of this formula, but we will now return to our subject.

All changes of grade exceeding 0.5 in 100 feet were rounded off by vertical curves calculated by the formula for a parabola. At summits these curves were usually made 600 feet long, but when

they occurred at the foot of grades, where the effect of the change is much more severe and dangerous through its liability to cause the train to leave the track or break in two, they were made from 800 to 1,200 feet long, according to the magnitude of the change. This is another point in construction which has not until comparatively recent times, received as much attention as should have been given it.

Our embankments were usually made 14 feet wide on the top at sub-grade, with side slopes of 1½ to 1, and the excavations 20 feet wide on the bottom, with slopes of 1 to 1 in earth, and ¼ to 1 in rock. These proportions are in very common use in this country, but, where the finances of a company will warrant an increase of one or two feet in these widths, it would undoubtedly be very desirable, especially on embankments more than ten feet high.

For all small water-courses, the double-strength culvert pipe of vitrified clay, made at St. Louis, Mo., was used. These are thicker and much stronger than the ordinary sewer pipe, the thickness being not less than one-tweifth of the diameter. Only pipes of twelve or fifteen inches diameter were used, and where one line was not thought sufficient to pass the water, two and sometimes three lines were laid. The pipe cost, delivered on the cars at East St. Louis, eighteen and twenty-four and three-fourth cents per lineal foot, and the handling and laying cost thirty-nine and forty-five cents per foot.

There are eleven Howe Truss Bridges, each a single span, one 94 feet, and the other 66 feet long between centers of end blocks. The chords and braces of these bridges were of yellow pine, the finances of the company not warranting the use of iron. The 94-foot span cost $2,650, and the others $1,550 and $1,700 each, for the superstructure alone. Pile abutments were used for all of these bridges except one, where, on account of rocky bottom, framed bents were employed. This course was adopted because, although the road ran for so many miles through a rocky country, and many thousand cubic yards of rock had to be removed, but very little could be found that was suitable for bridge masonry. For the same reason, there were but four stone culverts on the line, all of which were fine specimens of arches of four feet span under high embankments.

The Cairo, Vincennes & Chicago Railway is crossed overhead by a riveted iron girder bridge, 44 feet in length, resting on iron bents supported by stone piers. This bridge, on account of its unusually sharp skew of about 23° is quite an interesting structure.

It may not be out of place here to remark, in passing, that the writer's experience with this crossing has served to strengthen the conviction which had long been growing upon him that the time is fast approaching, if it has not already come, when all crossings of railroads at grade should be absolutely prohibited. Even with

the present great cost of an overhead crossing, it is a question whether it is not more than balanced by the diminished cost and danger of operation, and the rapidly growing use of automatic couplers, by doing away with the necessity of brakemen standing on the roofs of freight cars. This method of diminishing by about six feet the necessary clearance, and thereby reducing the cost of an overhead crossing more than fifty per cent, promises to hasten the day when a grade crossing will be a thing of the past.

With the above exceptions, all openings are crossed by pile or framed trestles, the former being used exclusively except on the Ozark Division, where in five cases the occurrence of rock bottom compelled the use of framed bents. These five cases included all the highest trestles on the road, one of them being 60 feet in hight. When these framed bents exceeded 20 feet in hight, they were built in two or more stories, the upper stories being of a uniform hight of 16 feet, leaving that of the lowest story to come what it might. The individual bents are stiffened by sway bracing of the usual form, and are tied together at each story by four or more horizontal ties, 8 x 8 inches, notched and bolted to the caps and posts. No inclined braces were found necessary, even for the highest trestles, though they would no doubt have added to the strength and security of the structures.

The caps of framed bents are secured to the posts by the usual mortice and tenon joint; those of pile bents are secured to the tops of the piles by drift bolts. The latter method of construction, though superior to the former, both in cost and durability, is not entirely satisfactory, on account of the difficulty of removing the caps when decayed. For this reason it is probable that both methods will eventually be superseded by the system of split caps, which consists of two pieces, 6 x 12 inches, placed from 4 to 8 inches apart, resting on shoulders cut on the sides of the piles or posts, and secured by bolts passing through both pieces and the post. Although this system brings back the shoulders, which are objectionable as affording a lodgment for water, the ease with which the caps can be removed for repairs, without interfering with traffic, will eventually overcome all objections.

The spans of the trestles were 15 feet between centers of bents, and the stringers extended over only a single span. This is not the best nor the strongest construction, but the difficulty and cost of obtaining long sticks in a territory which had been largely stripped of suitable timber, compelled its adoption as a general rule. The stringer under each rail consists of two pieces, 8 x 16 inches, packed 3 inches apart with a wooden packing block 18 inches deep and 4 feet long. The packing blocks are notched 2 inches over the caps, and thus serve very efficiently to keep the bents at their proper distance apart, and prevent any longitudinal movement of the stringers. But notwithstanding this advantage, this construction is objectionable on account of the large surface

which it offers for the lodgment of water. It would be better to insert iron spools or washers between the packing blocks and the stringers. Some engineers use the spools without the packing blocks, but in this case the longitudinal movement of the stringers must be prevented either by the use of iron clamps, or by drift-bolting the stringers to the caps, a very objectionable method, on account of the difficulty of replacing the stringers when decayed. In the case of a transfer incline, however, this construction may be unavoidable, as will be hereafter noted.

Any lateral movement of the stringers is prevented by spreading blocks 3 x 10 inches, spiked to the tops of the caps.

The ties are 6 x 8 inches, and 9 feet long, dopped one inch over the stringers, and spaced 15 inches between centers. There are guard rails, 6 x 7 inches, dopped one inch over the ties, and bolted to every third or fourth tie. These serve the purpose of keeping the ties from bunching, and preventing a derailed train from leaving the structure.

There are no side or jack stringers. These attachments are recommended by many of our best engineers, and are certainly very useful to the unfortunate pedestrian who finds himself confronted by a train on the trestle, where he ought not to be at such a time; but they add much to the cost and very little to the strength of the structure, and it is at least an open question whether they should ever be used.

The use of wooden trestles for crossing water courses seems to be in many cases unavoidable, especially by new companies struggling along with scanty means. They undoubtedly effect a large saving in the first cost of a road, but even when built in the best manner, they are open to very serious objections. The liability to accidental or malicious destruction by fire, and the necessity of constant watchfulness to guard against the insidious effects of decay, make them objects of suspicion, to be avoided whenever it is possible. The $180,000 which the Toledo, Peoria & Western Company paid for personal damages alone, arising from the disaster at Chatsworth in 1887, which was the result of the accidental burning of a small trestle, would have gone far toward equipping the whole road with first-class stone culverts; and who can foresee when or where such an accident may occur again? Where stone for a culvert and earth for an embankment can be obtained at any reasonable cost, a wooden trestle should not be permitted; and where stone cannot be obtained, a wooden box culvert may often be employed with great advantage. Twenty years ago such a structure would have been considered very bad practice, but recent experience on some of the greatest railroad systems in this country has demonstrated that it is safer and more durable than a trestle, and can be renewed without great difficulty, especially with iron pipes.

The most important trestle on the road is one which was built for the purpose of a transfer incline at the southern terminus of the line. As many of the members of this Society may never have had an opportunity to examine a structure of this kind, a brief description of this one may not be without some interest.

The object of an incline is to furnish a means of transferring a car or train from a railroad track onto the deck of a boat, and the reverse, thus answering the purpose of a bridge in transferring it across a stream. It consists usually of a trestle or rock embankment running down into the water of the stream to such a depth that at low water a boat can lie over it. If there is any current in the stream, the incline must of course point *down stream* as nearly in the direction of the current as practicable, as otherwise it would be difficult or impossible for the boat to use it. On this track rests a *cradle*, which is a kind of car whose longitudinal section is triangular in form, the lower sills being parallel to the incline, and the upper ones horizontal, or nearly so. This cradle is pushed down or pulled up to the incline by the locomotive until the track which is laid upon it is at the proper elevation above the water. The outer end of the upper chord of the cradle projects several feet beyond the main structure, and is attached to it only at the inner end, where there is a hinge joint, around which it has a free but limited vertical movement. The outer end is built in the form of a triangular recess faced with iron, into which a corresponding projection on the boat fits closely. An inclined apron projects from the brow of the boat, which, as it approaches the cradle, catches under the free end of the projecting chord, and lifts it up to its place. The boat and cradle are then secured together by turnbuckle screw bolts working in lugs attached to the sides of the two tracks. A car or train can now be pushed down the incline onto the cradle, and thence onto the boat, which conveys it to the other side of the stream, where it is drawn off onto a similar cradle and incline. This method of transferring cars is used very extensively on the Ohio and Mississippi rivers.

The boat may be built with either one or two tracks, but the latter is the more common construction. The incline also may be either single or double tracked, the latter being much the better where a double track boat is used; but when, for the sake of economy, only a single track is built, it must be located so as to fit the outer track of the boat, as otherwise this track could not be used at all.

The boat is usually made long enough to hold from six to eight freight cars on each track.

To enable the boat to land at the cradle, a row of clusters of guide piles is driven on the shore side of the incline. These clusters are driven from 25 to 50 feet apart, and should extend from a point opposite the lower end of the cradle, when it stands on a level with the top of the incline, to a point from 100 to 200

feet below the lower end of the incline, according to the length of the boat. Each cluster contains from three to five piles, driven about four or six feet apart, and drawn together at the top, and confined by strong chains, so as to make them act, as far as possible, like a single pile. These clusters should be driven with their outer faces at a distance from the center line of a double track incline equal to half the beam of the boat, unless, as is frequently the case, a landing barge is interposed between the boat and the guide piles, in order to distribute the shock of the boat over several clusters, in which case this distance must be increased by the width of the barge. In case of a single-track incline and a double-track boat, this distance must be increased by half the distance between the centers of the tracks on the boat. This last distance is commonly 12 feet, but in the "Geo. W. Parker," the boat used at Paducah, it is 14 feet 8½ inches.

The piles in these clusters are usually driven until their tops are from 15 to 20 feet above the track of the incline immediately opposite them, so that at high water many of them are entirely submerged. It is better, however, to have one or two of the piles on the boat side of each cluster project 8 or 10 feet above the others, so as to prevent the boat from dragging her guards over the tops of the clusters, to her possible serious injury. For a similar reason, notches should be cut on the boat side of the cluster piles into which the chains which confine them can be sunk, so as to prevent them from tearing the sides of the boat.

The extreme rise of the Ohio River at Brooklyn, from low water mark to high water, in 1884, was about 53 feet, and as it was determined to make the upper end of the incline one foot above high water, and the lower end 6 feet below low water, a total fall of 60 feet had to be provided for. As actually constructed, the incline will be, when completed, 1,538 feet in length, of which 1,290 feet have a fall of 3.4 feet in 100, and 248 feet at the lower end, which will be used only in low water, and will then be occupied almost entirely by the cradle, which has a fall of 6 feet or more in 100. An additional length of 420 feet of trestle connects the head of the incline with the brow of the bluff, on which the Brooklyn yards are located.

The entire incline is built upon pile, even through a cut several feet deep, which it was necessary to make.

A structure of this kind is subjected to very severe strains from drift-wood and ice, which sometimes pile up in enormous masses, and more than ordinary care must be taken to prepare it to resist these strains. For this reason, the plans in use elsewhere on the road were somewhat modified. The stringers were made long enough to cover two spans, and laid so as to break joints. Each stringer was secured to the caps by drift bolts; each tie was drifted to the stringers, and a stick of timber 6 x 6 inches was drifted to the outer ends of the ties to prevent ice or drift from catching

on them. The guard rails were omitted on account of their interfering with the movement of the cradle. In this particular, the writer felt constrained by the necessity of conforming to standards; but if he were building another incline, with entire freedom to carry out his own ideas, he would make the ties at least 11 feet long, and retain the guard rails for their use in binding the whole structure more firmly together.

The construction was carried on in the usual manner until the surface of the water was reached, 263 feet from the lower end of the incline, when a sudden rise of the river drove the workmen away, leaving them barely time to lay the steel rails on the lower end of the finished work.

As there was soon depth of water at this point sufficient to operate the boat, the further extension of the incline was suspended. A day was set for opening the road, and the work above water was completed, when a fall in the river, as sudden and rapid as the rise had been, compelled the speedy resumption of work on the lower end. We had but little over four days to prepare for passing over the first passenger train, and it was very important that the expectations of the management should not be disappointed. The piles for the river work were driven by a pile-driver on a barge. The cutting was at first done by a diver working with a hand-saw, under water, but this method proving very slow and unsatisfactory, a cross-cut saw was attached to a light triangular wooden frame, the apex of which was hung to the pile at such a hight that the saw rested against the pile at the proper hight for the cut-off. This was regulated by a vertical gauge on the bottom of which was a step for the saw to rest on. The sawing was then done by three men standing on a raft, one of whom kept the frame pressed against the pile, while the other two drew the saw forward and backward by means of long cords attached to its handles. With this crude and simple contrivance, the head of a pile was frequently taken off in fifteen minutes. A small rod with a sharp point was then driven into the center of one of the piles, and projected above the water. A drift-bolt hole was bored through the cap, which was then dropped over the rod and weighted down with chains. The diver swung it into its proper place over the piles, and guided the point of the long auger, with which a man on the raft bored the drift bolt holes over the center of each pile. Another small rod was inserted in each of these holes in succession, and over it a section of gas pipe was dropped down onto the cap. The rod was then withdrawn, and a drift bolt dropped down the pipe into the hole, and driven home with a heavy, flat-ended bar working in the gas pipe.

Now came what in some respects was the most difficult part of the work, the erection of the superstructure. In the case of an incline at East Carondelet, Ill., whose construction the writer superintended in 1882, the entire under-water part of the superstruct-

ure was framed in one section on rollers on the top of the out-of-water track, and then drawn down into its place by a tug. This operation required considerable time, and was therefore impracticable in the present case. The track was therefore framed in sections 60 feet in length, covering 4 spans. The first section was framed in the usual way, except that in the upper span the chord pieces were so placed as to inclose the stringers above and below. The joints were so framed as to come as nearly as practicable over the centers of the caps, but the care required to accomplish this, on account of the unavoidable irregularities in the driving of the bents under water, and the weakness which would be the result if the joints were not brought directly over the caps, led to the adoption of a different plan for the remaining sections. The spans were reduced to 13 feet, and the stringers framed in pairs without breaking joints, each pair being alternately inside and outside of the adjoining pairs above and below. The stringers being 30 feet long, each pair extended over two spans, and lapped 18 inches beyond the caps at each end, thus securing a firm bearing, independent of the adjoining pairs, even if there were a variation of a foot or two in the length of the spans. The holes for the packing bolts, which connected the adjacent pairs, were bored about half an inch larger than the bolts, so as to give the stringers a moderate hinge motion, by which they could adjust themselves to any slight irregularities in the hights of the caps, and thus secure a firm bearing.

Work under water can seldom be done with the same precision as on land, and some provision must therefore be made for unavoidable inaccuracies. The stringers were put together on the top of the finished track, the ties dopped and drifted onto the stringers, and the rails laid, and the section was then drawn into the water by the transfer boat, which supported the outer end, while the inner end was suspended from the cradle, and drawn back into its place by men standing on the incline. This last operation sometimes occupied several hours, on account of the difficulties which attend all under-water operations; and on one occasion the diver had his leg broken by being caught between the ends of the fixed and loose rails as they were slipping together. When the ends were once brought together, the fish plates were bolted on by the diver; the section was then weighted down onto each cap in succession, by pushing down the cradle; the stringers were drifted onto the caps; and the work was done.

This paper has extended to such an unconscionable length that the writer omits any description of the cradle which was used on this incline. He has, however, brought with him the plans of this, as well as several of the other structures on the road, for the amusement of any members of the Society who may choose to examine them. It was his intention to have copies made of all of these plans, as well as photographs of some of the structures and of

the natural features of the road, to present to this Society; but the want of time has prevented him from carrying out this intention. He hopes to do so, however, at some future time, and mentions the subject now simply for the purpose of suggesting that the exhibition and presentation of such plans might be made productive of much good to the members of this Society. If each member would at each meeting present the working plans of even *one* structure which he had actually built, we should soon have a set of plans in all branches of engineering, ranging from a board fence to a cantalever bridge, from which we might all get some useful ideas.

Engineering is very largely an empirical science, embodying the best results of the successes and failures of generations of experimenters; and he who expects to plan all the structures which he may be called upon to erect, without any regard to what others before him have done, will soon find that he has attempted to shoulder too heavy a burden. There is not one of us who is not liable to be called upon at any time to plan some structure with which he is not perfectly familiar; and if he could feel assured that in the rooms of this Society he could find valuable hints, if not just what he wants, in the experience there recorded, the Society rooms might in time become a Mecca toward which all our footsteps would gladly turn.

EMERY W. MUENSCHER, C. E.

RAILWAY LOCATION IN THE HILLS AND FORESTS OF MICHIGAN.

LOCATING a railroad line through the forests and among the hills of Michigan in a locality unknown to the engineer, is much like finding an unobstructed path through a dark garret, into which has been piled promiscuous heaps of boxes, barrels, furniture, and everything hard to climb over. While engaged in either occupation, you will be apt to run into something as disagreeable as it is surprising. This unexpected contact will breed thoughts that will hardly be orthodox, and if they are uttered at all, they would better be murmured in a low voice, while you are thus alone in the woods or in the dark.

Before much progress can be made in finding a good location, the country through which the line is to run must be thoroughly known.

The initial and objective points, and probably some places between them, have been decided upon by the business managers of a road, and the question of how to connect these points with a railroad running in the most direct line, with grades as nearly level as possible, and with the least expenditure of money, is referred to the engineering department.

All possible information relative to the topography of the district between these points, is gathered from maps and from people who are acquainted with the whole or a part of the country. The latter, however, should be taken with caution, as will be shown later.

The published maps of the northwestern part of the Lower Peninsula, which we have been able to secure, have been found to be unreliable in marking the location of streams, and in topographical data generally. But information gathered from people and maps cannot take the place of going over the country and becoming acquainted with it personally.

The really valuable information must be gathered from the field by the engineer himself, and placed upon a map of his own construction.

In places where no clearings have been made, the forests are so dense that only a few acres can be seen from a given point, and but little can be learned of the nature of the ground without a systematic examination of the whole region through which it is required to locate a railroad. I have been able to find no rule by which a feasible route can be marked on a map, before walking *over*, *around*, and *through* the hills and in the valleys, unless the information can be obtained from some one like our worthy President, who can mark the exact location upon a map for you. This cannot be called an exception to this lack of a rule, for his acquaintance with the Grand Traverse region was gained by the sweat of his brow.

In the northwestern part of the Lower Peninsula, where the writer is most familiar with the hills, there appears to be no system in their arrangement. The highest hills are mostly yellow sand with now and then a pocket of clay, and where we have made excavations, a few stray boulders have been found. Perhaps a general description of a part of the country will not be out of place here.

The elevations given have been reduced to hights above Lake Michigan, by connecting our levels with an elevation above the lake at Cadillac, furnished me by Mr. G. S. Johnson, Chief Engineer of the G. R. & I. R. R.

Beginning at the Muskegon River in the northwestern part of Clare County, where the water in the river in section 16 T. 19 N. R. 6 W. has an elevation of 429 feet above the lake, the ground rises by two terraces westward to a long stretch of pine plains having a thin growth of brush and jack pines. The first terrace is about twenty feet, and the second about thirty-five feet above the river. The plains rise about twenty feet above the second terrace, and make an ascent of only twenty feet in two miles and a half.

Just over in the eastern part of Osceola County, the plains border the clay hills which are drained by the Middle Branch of

the Muskegon and its tributaries. These hills have an average elevation of 560 feet, but are very rolling and broken, and are frequently cut into by swamps running back from the streams. In the northern part of Osceola County, on the divide between the Middle Branch of the Muskegon and the West Branch of Clam River, the hills attain an elevation of 645 feet. This is eighty feet above the nearest tributary to the Middle Branch, and less than three quarters of a mile from it. Here the material is sand and gravel.

The ground then drop ssixty feet in a mile and a half into the valley of the West Branch of the Clam. It then rises to the rough sand hills which have their summit in the southeastern part of Missaukee County and the southwestern part of Wexford County. The highest point in these hills over which we have run levels, is 818 feet. Other points which we missed must be thirty feet higher.

The highest point of grade on the Toledo, Ann Arbor & North Michigan Railway is among these hills (on section 18, T. 21 N. R. 8 W.), being 803 feet above Lake Michigan.

Dr. Winchell, in his "Topography of Michigan," says that the summit of the northwestern lobe of the Lower Peninsula is among these hills, but we have found places in the Brier Hills about twenty miles northwest of them which is ninety-seven feet higher.

These hills are composed mostly of yellow sand, and covered with a heavy growth of hemlock, maple, beech, birch, pine, elm, and a few other varieties of timber.

They are very rough and broken, cut up by deep dry ravines, running in various directions. Occasionally there is some clay at the bottom of a ravine which holds the water and forms a swamp.

They extend to Clam Lakes at Cadillac, and there present a bluff like appearance. The elevation of the water in Little Clam Lake is 701.5 feet.

A large flat area lying about eighteen feet above Clam Lake stretches out north and west of Cadillac for a distance of six miles. On the west side of this flat piece there are a number of small lakes, surrounded by soft ground, with a very uncertain bottom.

From this soft ground the land rises rapidly to a plateau seventy-five feet higher. In the southwestern part of Wexford County this plateau terminates in a lot of hills very similar to those just described. They are divided by the Slagle Creek. Those on the north side of the creek are called the Brier Hill Range. The lowest point along the summit of this range which we were able to find, had an elevation of 915 feet. They extend westward to within half a mile of the Manistee River, which is about 740 feet below its summit.

The Slagle Creek is a very rapid stream, having a fall of 426 feet in ten miles. Between the creek and Brier Hills there is a

terrace having about the same fall as the creek, and widening as it approaches the Manistee.

The Manistee River has an elevation of 196.4 near Sherman Village, and is 55.4 feet lower seven miles down stream. The banks on the east side are more easily reached than those on the west side, where a range of hills from 225 to 300 feet above the water lie close to the river. The streams running from these hills into the Manistee are very short, and afford but little means of getting out of the valley.

Among the sand hills most of the ravines do not seem to have been formed by streams of water, and they often terminate abruptly at the foot of irregular knobs from twenty feet to a hundred feet higher.

The courses of these ravines and depressions through which you may at first hope to find a practicable route, are often so irregular that even if they did not lead into insurmountable knobs, they would be useless on account of alignment and the heavy earth-work necessary to cut through the ends of projecting hills.

Many times, a line running directly across these dry ravines will furnish longer tangents, easier grades, and less earth-work than could be found by following the best of them. Such a line might be rejected by a railroad official who has no eye for elevations, if he were to walk over it, unless he was provided with a profile of an actual survey, with an estimate of the work to be done, to convince him to the contrary.

I do not doubt but that engineers who build logging railroads have harder work to make their employees believe this than do engineers employed by railroads doing a general transportation business. When the Government corners are standing in the woods, the location of hills, streams, or anything else can be determined with sufficient accuracy, in the reconnaissance, by pacing.

When riding over section line highways, diagonal roads, or logging roads, distances may be roughly found by measuring the circumference of a buggy wheel, and counting its revolutions. Courses are taken with a pocket compass and comparative elevations with a barometer. While making this examination, lots of information will be offered by people claiming to be acquainted with the country. It will come in all degrees of utility, from the general statements of the old settler who says, "This is a mighty RAVINOUS country," to a minute description given by a lumberman who will tell each forty his route traverses. Another old settler will say that the only way you can get through, is by following a ravine where he chased a bear last season. One of these "only ravines" proved by actual measurement to be nearly a hundred feet higher than ground already selected as holding the best elevations and alignment in that vicinity.

Don't be led too far against your own judgment by men who offer themselves as guides and pilots in showing you through the woods, over what they consider a sure way through a place of difficult location. If the guide is a land owner, he will steer you to a place which will be convenient for him to deliver logs, without much regard for good railroad location. If he is ignorant, there is no telling where he will lead you. I remember one of the latter class who after traveling through the woods several hours, caught sight of his own chopping, and wondered whose clearing that was.

Perhaps when you arrive in town, some lawyer will tell you what a delightful time he had trout-fishing in a stream somewhere near the place you have been looking line, and describe to you a good place for location.

If you should go to the county records, you might find a bit of history running like this: Twenty years ago a mossback entered an eighty near the trout stream. Some years later a non-resident began action against him for cutting the pine off of the adjoining eighty; and still later a big mortgage, with a squeezing foreclosure clause, against a mossback's eighty, and in favor of this lawyer for defending him in his logging enterprise.

If you could look at a picture of the near future, which the lawyer looks at through a blue cloud of tobacco smoke while he sits scheming in his office, you might see a railroad skirting along a mill pond lined with factories. Just beyond is a big brick block with a conspicuous sign of "Lots for Sale" hanging out. Inside the corner office on the ground floor, the lawyer sits amusing his customers by telling them how he used to catch trout down near the mill-dam before there was a tree cut, while his busy clerks are hard at work writing the descriptions of his lots in blank deeds for them. But it does not follow that all schemers are lawyers.

I mention these cases to call attention to the information offered to an engineer when he is in active duty in the woods, that he may apply his knowledge of human nature to search out the motive of his informer, before any valuable time is wasted in finding him actuated by some selfish scheme.

The most reliable information can be found from lumbermen who have done business over a large area, and who have located sleigh roads for long hauls.

In the last year's work, the man who gave us the most accurate knowledge of the country was a farmer who hired out in one of our corps as an axman, and said he had been employed by Mr. Steele in Grand Traverse and Benzie counties, in similar duties. But he had to be questioned to draw out what he knew. It is as true here as elsewhere, that proffered and gratuitous information and opinions are of the least utility. When you want to know something that is of value, it must be sought from people who are too busy to hunt you up to tell you what they know.

While engaged in the reconnaissance, enough should be learned to enable the engineer to draw very accurate outlines of hills, table-lands, valleys, ravines, and to mark the streams on his map, so that he can lay out a course over which to run a preliminary survey, with the assurance that a practicable location can be found near it.

In places which are unusually rough, such as running from a table-land into a deep ravine or valley where the descent is made among abrupt and irregular hills, cut up by ravines and gulleys, or in passing over divides like those found in the southeastern part of Wexford County, and adjacent parts of Missaukee and Osceola counties, a definite course for a preliminary survey cannot be laid down at first.

Several courses are drawn, over which the chief or locating engineer walks with a pocket compass in his hand, and over what seems to be the best route for his purpose. He marks his course on the ground by breaking off brush and fixing pieces of paper on saplings and sticks. In settled weather, an aneroid barometer will be found of great service in aiding a person to keep desirable elevations, but in changing and stormy weather, a good guess will be much more trustworthy.

Then, frequently, several preliminary lines have to be run before the best route can be selected.

At this stage of the work, a party is put into the field to run the preliminary line. In places which present no special difficulties, the preliminary line can be run with the same care that is exercised in running a line for permanent location, cutting down everything, that the tangents may be free from swings.

When the nature of the ground indicates that the preliminary line cannot be adopted as the located line, short tangents are run, without joining them by curves. In the rough places, the broken brush and pieces of paper are followed, improving the line as much as possible. The several lines which have to be run in these places should be connected, and the levels run from the same datum line, in order that a comparison can be easily and quickly made, as soon as the notes have been platted.

Tie lines are used to connect the preliminary line with Government surveys every mile, if possible; but if much hunting is required to find the corners to run tie lines, it will be better to omit them until so large a corps will not be hindered.

If the preliminary work is done with a transit provided with a gradient screw and level attachment, it will afford much assistance in determining the course of lines where the best elevations can be held, etc., and oftentimes help to fix parts of the preliminary line so well that they can be adopted for location.

Mr. F. Hodgman, in his article on "Surveying for Railroads," read before this Society in 1883, tells of the advantages of the gradient screw, in advance of the leveler. In the spring-time,

when flooded districts have to be crossed, and the water is too deep to make measurements, instruct the head chainman in the use of the carpenter's "six-eight-and-ten rule" of laying out right angles. Let him select a hub at a convenient point on the farther side, and lay out his right angle. Turn off 5° 43′, and let him place another hub at the intersection of a line at right angles to the preliminary line at his first hub and the line which is deflected 5° 43′. Measure the distance between the hubs, and multiply it by ten for the unknown distance. The natural co-tangent of this angle is 9.98931. In a distance of 1,000 feet, the error would be 1.07 feet, which is as close as most measurements are made in the woods on preliminary lines. This method of triangulation avoids chopping, and the computations are performed mentally, and the progress of the party interfered with but little. With a map drawn on a scale of 1,000 feet to the inch, and one or two good tie lines to begin with, courses of the preliminary lines laid down by the chief engineer can be scaled with a remarkable degree of accuracy by the aid of a good horn protractor. This saves the time of hunting up corners at quite a distance from the line, and calculating courses. When running around hills where pine choppings are covered with a thick growth of poplars and brush, so that the eye cannot penetrate more than six or seven rods, the locating engineer goes 800 or 1,000 feet ahead of the transit, selects the best place to run, and makes a noise, so that the line can be run toward him.

Every one knows that the valleys of streams should be followed when possible. Searle's "Field Engineering" and other text-books teach this and many other things which should be remembered in locating lines in the woods.

When the preliminary work has been finished, the line for location is run as soon as possible, using the map of the preliminary lines as the base of all work. I wish to emphasize what Mr. Hodgman says in his article, above referred to, against the "cut-and-try" method of locating.

Don't do it. It is expensive, takes lots of time, and seldom gives satisfactory results. Before going out to locate, everything which needs to be avoided, and all places which are desirable to use, should be located on the map.

In the woods, telemeters cannot be used to advantage. An engineer with two chainmen proceeds along the line, with no other instruments than a tape line and a pocket compass. Objects near the line can be located at right angles to a regular or plus station, by the engineer's placing himself in line, stretching out his arms in the direction of the preliminary line, then, with head erect, looking out straight.

If the line of vision does not strike the object to be located, move up or down the line until it does. With a little practice, a right angle can be approximated very accurately, and in less time than it would take a needle to settle. If the underbrush is thick,

or the object is too far from the line to be seen plainly, then the bearings are taken with a compass. Tie lines along section lines can be easily followed with a pocket compass, and with a fifty-foot tape line, good measurements may be obtained. When the topographical work has been completed, the notes are platted on the map of the preliminary line in camp or in the office. When this has been done, then all that you want and all that you don't want are arranged to show their exact relation to each other, plainer and better than could be expressed by volumes of words. If all of the work has been well done thus far, a location line can be drawn, and in most every instance followed.

No such progress can be made by cutting, trying, and backing out, when you have spent half a day with a full force of men to find that the position of some desirable spot has been miscalculated, or rather, misguessed.

Swings in located tangents are eye-sores which time does not cure, and almost everybody has too much pride in his work to allow any defect so noticeable to exist, if there is any way to prevent it.

It is easier to run a curve than a straight line. If any one doubts this statement, let him try it in a hilly country where there are occasional swamps, and all thickly timbered.

Short sights caused by ascending hills are to be avoided as fruitful sources of errors of this kind. The extra time used in cutting out overhanging limbs, so as to get a sight of at least 200 feet, will be well spent.

In swamps or in soft ground, long stakes are driven in the same direction the tripod legs are to stand, as a foundation for the instrument to rest upon to insure firmness while walking around the transit. A back flagman would better be promoted to the position of axman, for a back sight plumbed up behind the transit, with two pieces of thin card-board crossed and tacked to it, never neglects its duty. Sometimes it happens that two or three can be seen at a time, giving proof of the accuracy of the work.

The means employed to run a straight line would furnish subject-matter enough for an article too long to be included in this paper.

When an engineering force receives instructions to locate a line between two points, and to be ready to start a hundred men grading in a week, a thorough examination of the country cannot be made, and it will be wonderful if the best location is secured.

When such an order is issued, a connected location cannot be made. Parts of the line where men can be put to work to the best advantage are located first.

Under this condition, it is not always possible to have draughting tools when most needed to plat topographical notes, and whatever comes to hand must be used.

Once I received orders to locate a particular part of the line immediately, so that a gang of clearers could be started next day. Twenty miles of poor road lay between me and my drawing instruments. At a camp which was just starting in some deserted lumber shanties, I found an old rusty square and a piece of brown building paper. I appropriated them for my draughting. In the afternoon I went along the preliminary line, gathered notes, and in the evening platted them on the building paper. The map was drawn on a scale of 800 feet to the inch; angles were platted by using the table of natural tangents; and a piece of tough bark from a sapling, a pin, and a pencil, took the place of dividers to describe the curves.

The next morning I was able to run the located line ahead of the clearing gang.

GEO. L. WELLS.

WHAT A SPECIAL AGENT SAW IN OREGON AND NEBRASKA.

Mr. President and Gentlemen: —

I SEE that I am down on the programme to tell what I saw in Oregon and Nebraska while a special agent of the General Land Office, for the examination of surveys and the unlawful inclosure of the public land by cattle-men, and the fraudulent entry by pre-emption by the employees of these cattle-men or syndicates, in their interests. Being absent from home, I did not receive the programme from the Secretary in time to put down on paper what I saw, therefore I am compelled to give you a sort of extemporaneous speech of what I saw, to give you a general idea of the errors carelessly made in the public surveys in the State of Oregon, which I have represented by a diagram upon the blackboard.

I was instructed in the spring of 1883 to repair to Oregon and examine that portion of the Grande Ronde Guide Meridian, between the 4th St'd parallel S. and the 7th St'd parallel S., a distance of ninety-six miles, to ascertain where an error occurred of between two and two and one-half miles demonstrated by the running and marking of the 7th St'd parallel; and also the 6th St'd parallel west from the meridian, and nine townships adjoining near this line, in order that a correction could be made, also a full report made of my examination to the General Land Office.

Only field notes of the Grande Ronde Meridian, and the 6th St'd parallel south and extending west of said meridian, were furnished me.

My work was in Baker County, which is about 200 miles in length and 75 miles in breadth. I commenced work about latitude

44, and ran south, a full description of which will be given as my work progresses.

The *personnel* of my company consisted of two chainmen, a marker, a flagman, a cook, a teamster, and myself. At Boise City, Idaho, I provided myself with a heavy wagon drawn by four horses, a tent, cooking utensils, and provision to last five or six months; also necessary bedding. We left Boise City on May 4, 1883, and wended our way down the valley of Boise River, which is a very fertile valley, but sparsely settled; and the second day we reached Snake River, the boundary between Oregon and Idaho. This swift and turbulent stream, about one-half mile wide, we crossed on a ferry. It was then about sixty miles east of the point where I was to commence my labors. We were in a wild, unsettled country, rough, hilly, mountainous, stony, and rocky, destitute of timber and water, a wilderness, a treeless, God-forsaken waste. There was no one to inform me as to the location of the Grande Ronde Meridian, or how I was to get westward over the countless hills. They appeared impassable, but we knew we had to get there, so we pushed westward. We could make no calculations as to the distance we could make daily; that depended upon fuel and water. Our fuel was sage brush and grease wood, which grew from three to four feet high, the largest being not more than four inches in diameter at the root, with a broad, bushy top. The water when found was impregnated with alkali, which was not palatable. At last, by the assistance of a cow-boy, we found a township corner twelve miles east of the much coveted meridian, and when we reached it, we were eighteen miles north of the 4th St'd parallel. This we re-traced till within six miles of the initial point, when we encountered the vast hills that bounded the Malheur River, — rough, rocky, steep, and treeless, and giving an impression, upon the mind of a common Michigan man, of desolation absolute. Now came the tug of war, to get our wagon and supplies down into the valley of the Malheur River, which we afterwards learned was very narrow, and the stream very swift. I instructed the teamster and cook to look for a canyon or pass through these hills into the Malheur Valley, and we would continue our course south. We soon found that it was impossible for us to keep the line of the meridian, on account of the local attraction from the basalt rock, which was very hard and flinty, and strongly impregnated with iron; — we were lost in these vast hills! About three o'clock we concluded that we would better look for our wagon. We took our back track, and, to our surprise, at dark we were obliged to camp. I had instructed our cook to fire a gun every ten minutes after six o'clock for two hours, so that we could find where he had camped. He obeyed orders, but not a sound could we hear in those everlasting hills, except the yelp of the coyote, or prairie wolf. I said we camped,

but we only stopped, because darkness compelled us to; not a drop of water near, not a morsel to eat, and not a blanket or anything to lie down upon. We built a fire with green sage brush, which we cut with a jack-knife, and tried to keep warm; but we burned upon one side while we chilled upon the other, — at least it was more comfortable to change sides. The next morning at twilight we discovered that the ground was white with frost. That was a long, dreary, hungry night, and I thought of "sweet home" in Michigan, and I thought of words some would term adjectives (but of course I did not use them) as I laid upon the cold, hard ground, with nothing but the canopy of heaven over me, turning over trying to thaw out.

About ten o'clock the next day, by the assistance of the cook's Winchester, which made the welkin ring, we found our wagon, and did full justice to pork and beans, taking our supper and breakfast together. The remainder of the day we spent in searching for a place to get our wagon down into the valley of the Malheur River. During the day we discovered what we learned afterward to be the trail made by the hundred wagons of a colony that emigrated from Missouri in 1842 to Willamette Valley in Oregon, and the ruts made by the wheels could be easily traced yet. At the point where we found our wagon, we found the remains of wagons, stoves, and cooking utensils; for these same emigrants became lost when near their journey's end, got out of provisions, and were living upon the flesh of their mules, when friends residing in the Willamette Valley searched for them and found them, and rescued them from starvation. Somewhere upon their trail they found gold in large quantities, but it had no value when they were lost, and on the eve of starvation. Several of that party have prospected for that find from year to year, but their search had been fruitless up to 1884.

When once in the Malheur Valley, we were about ten miles up stream from where we found the line of the Grande Ronde Meridian. We retraced our steps to find the point we left the night before. By diligent search, and by the aid of piles of stone which we had placed upon the highest points, we found it, and by the aid of range poles with which we had previously provided ourselves (the magnetic needle had ceased to be of any use to us, on account of local attraction), we were enabled to find the initial point, being the 4th St'd and the corner to township 20 S., between ranges 39 and 40 east, and one mile south of the Malheur River. Finding that we could not trace the meridian farther, and that our wagon was no longer available, the country being so rough and broken, I at once repaired to Malheur City, a small mining town that we had learned was about fifty miles north, ordered a new Mountain Transit with solar attachment from the well-known house of W. & L. E. Gurley, of Troy, N. Y., and purchased five ponies, one mule, and pack saddles for nine horses. The mule I rode myself, it

being much surer footed than a horse, which was of vital importance to me when climbing the steep hills and rocky peaks, in places almost impassable, that we were to encounter upon the route. Some of them were composed of shale rock which would give way under our feet, and to avoid them was next to impossible.

I had also to examine the 6th St'd parallel west for twenty-four miles, to ascertain if it was a true east-and-west line, as the error might have occurred in running it. During the time I was waiting for the arrival of my Mountain Transit with solar attachment, we employed our time in trying to trace the meridian with range poles, to see if we could discover any corners on this line; but the search was fruitless. This line for twenty-four miles was run in the fall of 1864, but the surveyors were scared out by the Bannock Indians, who were on the war-path. The work was resumed and finished in 1866. Field notes of this meridian and the 6th St'd parallel S. were furnished me, and this line was represented to be a N. and S. line, with the exception of six miles offset to the east to avoid a spur of the Blue Mountains.

In due course of time my solar came, and we ran twenty-four miles, and fell east of the township corners on meridian three chains; ran six miles farther south, found the corners well marked, and intersected what should have been the 5th St'd parallel, which I found upon investigation to start forty chains west. Thence I ran south eighteen miles; thence an offset east of six miles; thence south twelve miles to the east end of the 6th St'd parallel south. From this point seven miles south, and a half mile east, the 6th St'd parallel S. runs east, being an offset east of one-half mile. This parallel is located one mile farther south than it ought to have been, but there are no notes given of the first mile after leaving the 6th parallel. Evidently it was not measured. Here was an error of one mile south on the meridian. At one-half mile east and one mile south of 6th parallel I found the meridian, and then started south, and at a distance of twelve miles I was lost; could find no trace of the meridian. Did I say lost? I was not lost, it was the meridian; but after a search of several days, thirty chains farther south, and 6.50 chains east, I again found the meridian, and traced it south till it intersected the 7th St'd parallel S. at a distance of eighteen miles. In running this line, several errors cropped out besides the excess of about 1.28 chains. In the last eighteen miles there was about one chain to the mile excess. The west line of township 30 S. of R. 41 E. was not run by the United States Deputy Surveyor, as he reported to the Surveyor General of Oregon that he could not find the Grande Ronde Meridian, because the Indians undoubtedly had destroyed all the corners; hence this error. The south line of said township commences one mile too far south; hence another error.

Also the west line of township 32 S., R. 41 E. is one and one-half miles east from the meridian, and starts south 30 chains too

far. I found in my examination that the N. E. corner of T. 33 S., R. 41 E., extended 6.60 chains E. of the S. E. corner of T. 32 S., R. 41 E., and 30 chains south, which is a very grave error, — of course the 7th St'd parallel S. is established one mile too far south. I examined the 6th St'd parallel S. west and found it a correct line.

I examined T. 26 S. and R. 37 E., and found it had never been surveyed. I suppose that this order was to convince the authorities that ordered the survey whether I made up my field notes in the field or camp, but the result was that I was not "caught napping."

In my examination of the interior lines of T. 25 S., R. 39 E., running N. and S., when I struck the north town line, I was 40 chains west of the section corner, caused by the set-off west on the south boundary. This will produce an error in all the townships west of this. The W. half of this township never was surveyed, being exceedingly rough. A United States deputy surveyor had a contract of surveying adjoining my work. I saw him at work, and he ran east, west, south, and north in subdividing, as most convenient, hardly ever setting one fourth post corners; never, when he did not chain.

This, after two seasons, finished my examination of the work assigned me by the Commissioner of the General Land Office, when I made a full and comprehensive report, as ordered by that office. My work was very much retarded by the errors that I found in the field. I was not able to examine more than four miles a day, on an average. Our work was a great distance from fuel and water, as there was no water excepting streams that were very few, and water standing in the pools, sinking and not to be seen again for miles. There was no timber excepting some little cottonwood along the streams, some willow, sage brush, and grasswood for fuel. A kind of bunch-grass which is very nutritious grows upon the hills and in the valleys, hence the raising of cattle and horses has been a great industry in the past, and a source of much profit; but this bunch-grass is fast being trodden and eaten out. This grass begins to start in February, and is dead and dried up by the first of July, but there being no rain or dews, retains its nutriment till new grass comes. Young cattle and horses do not have to be fed.

The streams are fed by the melting of the snow upon the mountains, and the arable lands of the valleys are irrigated by the same.

The inhabitants have to depend altogether upon irrigation, as there are no rains; and thunder and lightning are unknown. Wheat, barley, oats, and potatoes yield enormously; but the climate is too cool for corn, as it will not ripen. Wheat yields from fifty to sixty bushels per acre, which would seem to the Michigander to be incredible. Winter wheat is the only kind raised. The winters are mild, the thermometer seldom reaching zero, so it does not freeze out. Water from the ditches can be put on or taken off at

pleasure, so it is not affected by drouth. The nights are cool, which is favorable to the growth of wheat. There are no rains or winds to destroy the blossom. The heads are very long, and every place in the head has a kernel. Silica in the soil stiffens the straw so that it never lodges. The kernels are very large, plump, and heavy. Cattle and horses have to be herded, as there are no fences.

The Malheur River proper has three branches, is shallow, very wide and swift, and empties into the Snake River. Some of its fish are of the salmon species that come from the Columbia River, via the Snake. Its valleys are very narrow, fringed, and hemmed in by rugged, steep bluffs. The Owyhee is a very swift river, narrow and shallow, with steep, rugged bluffs. The Snake on the east is a very swift, boisterous river, the bottom being filled with rocks, and in consequence is not navigable; and I doubt whether any steamboat could stem the current, if free from rocks.

We saw several hot, boiling springs, and the wonder was whether caused by chemicals or internal fires. This country, no doubt, has been subject to great volcanic eruptions in ages past, as I found stone of a flinty nature that showed the effects of fervent heat, and sea shells on the highest peaks.

The climate of Eastern Oregon is very mild, all that one could wish. The nights are cool, requiring considerable covering, but in the morning one rises refreshed, and the air is balmy and bracing. No bilious diseases, no stretching and yawning, as in Michigan; one always has a good appetite as soon as out of bed. After we left Boise City, when we put up our tent to sleep in, we invited our teamster to "turn in" with us, but he declined, saying that he "preferred the pure air out doors." Before we reached the meridian, we ceased to put up our tent, and camped out till about the first of November. We had plenty of venison and antelope and jack rabbit that our cook killed with his Winchester; also trout and salmon. The boys spent their Sundays playing pedro, as we got nothing to read for weeks, being from 50 to 100 miles from a post-office. I busied myself straightening up my field notes.

Malheur City is a small mining town, and the mines that have been abandoned by the whites are worked by Chinamen. Water was brought in ditches and flumes for over 100 miles, constructed by a company from Chicago at a cost of $250,000. I became acquainted with a Chinaman, a contractor, who could speak very good English, and he gave me much valuable information about China and the Mongolian race. These Mongolians were a very industrious and inoffensive race. Notwithstanding their foul habitations, they practiced daily ablutions. They bathe as if it were a sacred duty, and in the winter they would cut holes through the ice to find the necessary water. The cue they universally wear, they regard with patriotic pride. It and the tonsure were introduced into China in 1644, as a mark of acceptance of subjection to

the Tartar rule, and enforced by the favor of the court; and those who refused to wear it were in some cases put to death. At length the mark of derision became the badge of honor, and now every Celestial carries this flag of his country, no less dear than his own head. They worship idols, and are slow to be converted to Christianity, and slow to learn to speak our language, or to understand it. Here is a specimen of some poetry, attributed to one of the Chinese scholars while being taught at a Christian mission: —

"How doth the little busy bee
Delight to bark and bite,
And gather honey all the day,
And eat it up at night."

While in Malheur City, I was asked by a United States deputy surveyor if I did not want the best cup of tea that I ever tasted. If I did, he said, just step into a Chinese restaurant, where I would get it. I consented, and after being comfortably seated at the table, I was asked if I did not want some soup. I told the waiter that I would take some, and it was so good that I took the second pint bowl, and I thought it the best soup I had ever tasted. After leaving, the deputy asked me how I liked the soup, and informed me that it was rat soup. "Yes, made of rats!" he said with emphasis, and about then and there my stomach heaved and rolled, while my friend tried to console me by saying that I had eaten more filthy things than this; for illustration, the dung-hill fowl and the hog. The illustration was well taken, but that did not settle my stomach. It required time, and it brought to my mind the story of the old lady who said, as she kissed the cow, "It is just as one is brought up."

These Chinamen who were digging for gold found the tooth of a mastodon, that weighed four pounds. It was ten feet from the surface, in gravel, in a good state of preservation, and had to all appearance lain there for ages. The climate of Eastern Oregon was all that one could desire, — days not overly hot, very temperate, the nights cool, requiring considerable covering, no mosquitoes, no reptiles. The air is pure and exhilarating, and it is a pleasure before sunrise to inflate the lungs with this pure air; but one has to be careful, if his vest is buttoned up tight, that he does not in a thoughtless moment burst the buttons off.

During the examination, before the arrival of my solar, as we were riding in single file, some cow-boys from a ranch about three miles distant discovered us in the distance, and also seeing me seated upon my mule upon a peak about 500 hundred feet high, "taking the country in," they took me to be the "big Injun," watching the movements of the whites. They reported to the settlers about twenty miles west of us that there were Indians in the country, and that they would better fly for safety. In the excitement, they left everything, and went to a fort that had been

built by Uncle Sam upon the Malheur Indian Reservation, the Indians having been removed previously. Men well armed came to watch the movements of "the Indians," but they were sure to keep their distance, so as to be doubly safe. One evening, two of my employees went to the ranch before mentioned to get some buttermilk, and to their astonishment found two cow-boys armed with Winchesters, standing as sentinels or guards, while several inside were eating supper with Winchesters at their sides. They informed the boys that there were Indians prowling about, and that they were liable to be attacked and massacred at any time. When they had fully explained what they had seen, and the boys had informed them that it was a company of surveyors that they had seen, they were surprised, and could hardly be made to believe it. They intended that night to make a raid upon us, and probably some of us would have been made to "bite the dust." Had it not been for buttermilk some of us would have gone "where the woodbine twineth." This occurrence made some of my boys timorsome, as they said the Indians might be lurking around, for aught we knew. This Indian scare even crept into the newspapers, but the truth of the matter did not get there. When the truth of the scare was reported at the fort, the settlers returned to their homes.

One day while riding horseback, I saw in the distance what appeared to be a city with its lofty spires. On approaching it, I found it to be a very curious formation, standing out in the valley of the Malheur River in bold relief from the surrounding bluffs, several hundred feet high, composed of several layers of sandstone, chalk, and basalt rock, and having been worn into almost every shape that the imagination might picture, by floods and stormy weather, and the hand of time had carved it into the most curious and fantastic forms, lofty domes, pinnacles, and fluted columns, resembling at a distance the ruins of an ancient city or cathedral in the midst of general desolation.

Having received a telegram from the General Land Office to report at Valentine, Neb., for duty, I then left Oregon; but I will say that on my way, crossing Snake River, a bridge was being built by the Oregon Short Line, having three abutments sixty feet high, the center one being very difficult of construction, as the river was so swift. They were constructed of cut stone shipped from Cleveland, Ohio. The bridge was to be built of iron, but the chief engineer of construction, who had been chief during the construction of the Union Pacific, had made a mistake of one foot in length of one span, which delayed the construction for some time. That engineer was informed that his services were no longer wanted.

I arrived at Valentine, a place of 600 inhabitants, situated upon, and at the then terminus of, the Sioux City and Pacific R. R., west of Omaha, Neb., 300 miles. There I found instructions to provide

myself with the necessary outfit and reliable men, whom I would better arm well, and proceed at once to northwest Nebraska, giving the township ranges, etc., 200 miles distant, to make an accurate survey of all inclosures by wire fence and otherwise, of Government lands by cattle-men, and also to examine all fraudulent entries, homesteads, preemptions, etc., as it had been reported to that office that Government lands were being unlawfully fenced in by cattle-men, and fraudulent entries made, and that homesteaders and preemptioners were being "frozen out," or forcibly ejected, if they attempted to settle within the inclosures. At the close, I was to make a clear and explicit report of the result of my examination. The United States deputy surveyor, who had the season before surveyed that country, had cut the wire fences to allow the teams to pass, and had let the cattle-men's stock away, requiring much time and expense to recover them. By so doing, the deputy surveyor had incurred their displeasure, and they had placed notices upon the fences, "Death to the son-of-a-bitch that again cuts our wire fences." Hence the order from the Department to arm my men to fight. I had not enlisted to fight, — no bounties were offered, — but having learned the character of cattle men and cow-boys while in Oregon, I preferred to adopt the pacific course, and I found that it won. The latch string of the cabin I ever found hanging on the outside of the cabin door, and the inmates were always ready to give us any information desired, and to give us shelter or anything we needed.

I hired a man, with a wagon and four good horses, who acted as teamster and cook, and three other men, two chainmen and a flagman; bought a tent, stove, and provisions to last us the round trip. We took along about forty bushels of corn to feed our teams, started out on October 6, 1884, and reached Pine Ridge, Indian Agency, 120 miles distant, on the 12th (the country unsettled), just over into the southern part of Dakota. Dr. McGillicuddy, agent, received us kindly, and entertained us very pleasantly, giving me some really valuable information about the character of the Sioux Indians. He pointed out to me the Indian chief that claimed to have killed Gen. Custer. He was a sour, coarse, revengeful-looking being, painted, wearing feathers on his head, and beads, cheap jewelry, etc., on different parts of his person; calico shirt, blanket, buckskin leggings, and moccasins. He informed me that there were about 7,000 Indians, old and young. The Government clothes and feeds them. They consume the beef of over 6,000 three-year-old steers yearly. The Indians kill and dress the beef, and it is then dealt out by the Commissary. The Indians are well fed, having in addition, flour, sugar, coffee, yeast, salaratus, and even soap, and the necessary cooking utensils. At this Agency there is a police force of 100 Indians, well armed, drilled, and dressed in Uncle Sam's uniform, and paid by that gentleman. There are also two schools here to teach them to read, write, cook,

and sew, taught by two maidens from Chicago. I spent half a day in the school, and it was amusing to see the proficiency they made in making pictures, but they were slow in learning our language, hence slow to learn to read and to spell. Several have been sent to Carlisle, Pa., to school, but the confinement did not agree with them, and they often returned with consumption, and soon died.

The Government furnished these Sioux with 500 new wagons and double harnesses, and they broke their ponies and drew their flour and groceries from Valentine at $1.25 per hundred, and the Government paid them for it. Some of them dressed like white men. When I was there, 6,000 steers were delivered by contractors at five cents per pound, to a United States Officer (Captain) in the regular army, and weighed, averaging 1,000 lbs. each. Mc Gillicuddy was afterwards accused, upon pretty good authority, of manipulating the scales so as to make each steer weigh 25 pounds heavier, which would make 150,000 pounds gain, and at 5 cents a pound would amount to $7,500, which was pocketed by the agent and seller; but inasmuch as it came out of Uncle Sam, it was all right.

Congress sent a committee of seven members of Congress to investigate the several Indian agents in the northwest, and while investigating this Agency, taking testimony, etc., one Indian contradicted another. The lie passed, and tomahawks were raised and knives drawn, and for a few minutes an outbreak seemed imminent, but Mc Gillicuddy rushed in bravely and quelled the seeming outbreak. It was said that Mc Gillicuddy told the committee that his timely interposition saved an outbreak, and had there been one at that time, not a white would have been left to tell the story. The next morning that committee left the business they were expected to finish. When they arrived at Valentine, I talked with several members of the commission, and from the tone of their talk they believed that they had barely escaped with their scalps. I talked with Holman, Chairman of the Commission, who was from Indiana. He is rather small in stature, aged about 65 years, and is known in Congress as the "Chronic Objector," as he will not allow any bills to come up unless in regular order. He said that he slept with both eyes "wide open," after he saw those tomahawks and long knives gleam in the air. The old man was evidently scared. They all thought their time had come. I never learned what they reported in this special case to Congress, but I think that they were evidently "sold out" cheap.

While visiting this reservation, Dr. Mc Gullicuddy took me to some Indian tents. There I saw squaws at work dressing or preparing buffalo-robes for market. He informed me that when these hides were first taken from the animals, they must be stretched and dried flesh side up. If not in this condition, when the squaws received them they have to do it. After they are thoroughly dried, the squaws take all the flesh off and reduce

them to an even thickness with an instrument, which for want of a better name, may be termed an adz. It was a little thin piece of iron about two inches long on the edge, and two and one-half inches deep. This was firmly tied to a piece of the thigh bone of an elk, and was used the same as a garden hoe. When the required thickness was obtained, the flesh side was covered with a preparation of lard, soap, and salt, and the robe was then rolled up and laid by for two or three days. It has then to be unrolled and again stretched on a frame like a quilt, with the flesh side to the sun. In this shape it was scraped with a thin oval-shaped piece of iron or steel, resembling a kitchen chopping-knife without the handle; this process usually lasted about two days. The robe was then taken from the frame, and drawn across a rope until it became thoroughly dry and soft. This last process made it very pliable, but required a good deal of time and strength; but it rendered the robe ready for market. I bought a very large one, costing eleven dollars. I brought it home and could have sold it for forty dollars. The squaws laughed when I pulled out my note book and began to write, being evidently as much astonished and interested as I was. They looked with wonder at the book, pencil, and the words I wrote. The lazy bucks just stood and looked on, while evidently the squaws always did the work, were willing to do it, and the Indians willing that they should. An Indian is constitutionally opposed to labor. He is evidently "tired" all the time. It is my opinion that the Indians will never make farmers, dividing their lands in severalty and breaking up their tribal relations will be a failure. But this is a problem yet to be solved, and it has been the study of the best minds in the nation for years.

After we left the Agency, the first night that we camped we saw about a dozen squaws with a span of ponies and a wagon without any box upon it, only a few boards. They were gathering some kind of berries, but their team balked coming down the hill. Not a step would they take downward. The squaws hollowed, and yelled, and whipped, and tried to push them down hill, but they would only push backwards (the first time I ever saw horses balk coming down hill). I sent my boys, and told them to unhitch the team from the wagon and draw it down. They did so, and the squaws laughed and showed their appreciation as best they could. They camped near us, and used water from the spring. The next morning they had their breakfast before we did, and a young squaw, probably eighteen years of age, her hair nicely braided and her head and face painted, and dressed in a sort of blue woolen Indian cloth, with beads around her neck, and brass finger rings on her fingers, in company with her mother, paid our camp a visit while we were eating breakfast, and stood around our camp fire. This young maiden watched the boys, and after breakfast she, by direction of the old lady, handed each some berries, when the old lady laughed and seemed very much pleased.

What they meant by this we could not conjecture, unless it was Indian love. We left that morning, "Westward, Ho!" and arrived that night at Camp Robinson, where about 1,000 United States troops were stationed to watch Indians.

On the 16th of October, we were in Hot Creek Valley, a distance of 200 miles west of Valentine, where I found six inclosures, averaging from 5,000 to 25,000 acres, and pasturing from 400 to 1,000 horses, and from 5,000 to 15,000 head of cattle each; but they pastured the surrounding country, only keeping these inclosures for their riding horses and the fat cattle that were to be sold. I then went south over a spur of the Black Hills, about twenty miles on to the Niobrara River, and surveyed around a ranch that contained 62,000 acres in its inclosure, and was forty-five miles around it. We had to camp on one side of the river, where we could get wood and water. It took us ten days, and as we were obliged to travel from ten to fifteen miles each day to our work, we took a team. We borrowed dry pine wood of the owners of the ranch, who had to draw it fifteen miles from a spur of the Black Hills. This company, of which A. S. Hewitt, of New York City, was president, had 16,000 head of cattle and 1,500 head of horses. This ranch bordered on and extended into Wyoming. Ten miles from this, down the valley of Niobrara River, they had another ranch of 16,000 acres; they had very good buildings upon all these ranches, built of pine logs taken out of the Black Hills, which were timbered with pine, and would afford plenty of timber and lumber for the surrounding country for years. The land was generally prairie, which raised a great amount of grass; and the pasturage was rich, but in many places the water was impregnated with alkali. The country was well watered with good springs and brooks, and I think, all things considered, is the best part of Nebraska.

During the summer of 1885, nearly this whole country was preempted and homesteaded, and by order of the General Land Office, the wire fences had to be taken down, and then there was an emigration to Montana, to "other pastures new." In the fall of 1886, the Sioux City & Pacific R. R. had extended their road from Valentine west up the valley of the Niobrara River, and built a depot where we camped at the A. S. Hewitt ranch.

We found many fraudulent preemptions by employees of these cattle-men, that I prevented from proving up at the Land Office at Valentine, being in that land district, and being located some six months at Valentine. I prevented many frauds on Government lands.

We found in one place, called the "Bad Lands," that the ground in the spring was so soft that it was impassable with wagons, and nearly so on horse-back, being of a clayey nature, soft and sticky, and said to load the wheels down in going a short distance, so that the wagon could not be moved. It would shake

like liver, but in the summer it became hard. Petrified frogs, mud-turtles, and fish were numerous. I saw a petrified mud-turtle that weighed 25 lbs. I also saw hundreds of the heads of buffaloes which had probably been killed by the Indians, but I saw none alive. They are of the past, — have followed in the wake of the mastodon.

I think that most of the land passed over by me is better adapted to raising stock than grain, as the elevation is too great for corn. Good wheat has been raised, and no country excels it in raising potatoes, barley, and oats.

Wild game is plenty, such as deer, antelope, wild geese, ducks, prairie chickens, and grouse, and the streams abound with excellent fish.

I finished my examination on the 20th of November, and turned my face toward Valentine. The weather had become cold and disagreeable to camp out. We were just one month too late, and on the morning of the 24th, six inches of snow laid upon the ground, and the thermometer was 12° below zero. Then we appreciated our tent and stove. We arrived at Valentine, Dec. 31, well satisfied that we could now appreciate comfortable quarters.

ISAAC TELLER.

Mr. Appleton. — "Are these river valleys generally fenced in?"

Mr. Teller. — "No, sir, they are not. The valleys are generally very narrow."

Mr. Appleton. — "Each valley, then, would have but one owner, would it?"

Mr. Teller. — "In some cases it had several owners."

Mr. Appleton. — "Are these valley ranches large? Are they not generally owned by poor people?"

Mr. Teller. — "Yes, sir, generally owned by poor people. The lands in those valleys are extremely rich and fertile."

Mr. Appleton. — "Have they any legal claim on the land?"

Mr. Teller. — "They are mostly homesteaders."

Mr. Appleton. — "They have no schools, have they?"

Mr. Teller. — "No, sir."

Mr. Appleton. — "Where did you find the pine?"

Mr. Teller. — "In northwestern Oregon. The geological aspect of the country looks as though it had been thrown up at some time. I found shells that were carried there from the sea. The air was very pure, and you could look upon the mountains a hundred miles distant, and sometimes we saw the mirage. At one place when I was traveling on horse-back one day, I saw in the distance what appeared like a city, but come to get up to it, it was columns of basalt, which looked like church spires."

STEEL TAPES.

It doubtless may be a matter of some interest to surveyors to see a comparison of the steel tapes sold as accurate measures, with a standard United States measure.

The standard in question is a brass yard of a certain number, furnished our State by the Treasury Department at Washington, as a standard yard. It is of exact length, at a temperature of 58.4° F., and is both a line and end measure.

The tapes in question were kept in the same room with the standard for some time, and were of the same temperature as the standard when making the test.

Three tapes were tested, No. 1 being an English tape, with graduations etched on the steel. No. 2 was graduated by soldering on babbit metal, and stamping the graduation on that. No. 3 is a tape graduated by puncturing holes through the body of the tape, and putting a rivet through at every point.

The report of my assistant, showing how the tapes were calibrated, is respectfully submitted. Yours,

R. C. Carpenter.

The accuracy of three different makes of steel tapes was tested as follows, with regard to graduation, calibrating them with a United States standard yard measure: The method of making the test was to have a person hold the back end of the tape exactly at the mark, while another exerted a strain of ten pounds on the tape, and a third person noted the variations. We were able to test only forty-five feet of the tape No. 1, owing to a break just beyond the forty-fifth foot. The following tables will show the variation for each foot in decimals of one inch.

TABLE SHOWING VARIATION OF THE NO. 1 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	+ .035	13	+ .05	24	+ .03	35	+ .01
2	+ .04	14	+ .04	25	+ .03	36	+ .005
3	+ .06	15	+ .05	26	+ .025	37	+ .005
4	+ .06	16	+ .05	27	+ .02	38	+ .005
5	+ .06	17	+ .05	28	+ .03	39	.000
6	+ .05	18	+ .04	29	+ .03	40	.000
7	+ .06	19	+ .04	30	+ .03	41	— .005
8	+ .07	20	+ .035	31	+ .035	42	— .01
9	+ .06	21	+ .03	32	+ .025	43	— .01
10	+ .065	22	+ .035	33	+ .01	44	— .01
11	+ .07	23	+ .04	34	+ .01	45	— .015
12	+ .05						

The length of No. 1 Tape is 44 feet 11.985 inches; temperature, 70° F. Total error, .015 inches.

TABLE SHOWING THE VARIATION OF THE NO. 2 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	+ .02	14	— .01	27	+ .00	39	— .01
2	+ .01	15	— .01	28	.00	40	— .01
3	.00	16	— .01	29	.00	41	— .02
4	.00	17	.00	30	.00	42	.00
5	— .03	18	.00	31	.00	43	.00
6	— .03	19	+ .01	32	+ .01	44	+ .01
7	— .02	20	+ .01	33	.00	45	+ .02
8	— .02	21	.00	34	.00	46	+ .02
9	— .02	22	.00	35	.00	47	+ .02
10	— .03	23	+ .01	36	.00	48	.00
11	— .03	24	.00	37	.00	49	.00
12	— .03	25	+ .01	38	.00	50	— .01
13	— .02	26	+ .01				

The length of No. 2 Tape is 49 feet 11.99 inches; temperature, 70° F.

TABLE SHOWING THE VARIATION OF THE NO. 3 STEEL TAPE.

Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.	Standard feet.	Variation of tape.
1	— .04	14	— .055	27	— .200	39	— .190
2	— .05	15	.065	28	— .230	40	— .240
3	— .03	16	— .105	29	— .200	41	— .290
4	— .05	17	.065	30	— .220	42	— .210
5	— .03	18	— .095	31	— .270	43	— .230
6	— .05	19	— .095	32	— .220	44	— .250
7	— .01	20	— .135	33	— .220	45	— .260
8	— .05	21	— .155	34	— .220	46	— .260
9	— .05	22	— .155	35	— .240	47	— .260
10	— .09	23	— .155	36	— .230	48	— .250
11	— .10	24	— .155	37	— .170	49	— .270
12	— .055	25	— .205	38	— .180	50	— .390
13	— .055	26	— .235				

The length of No. 3 Tape is 49 feet 11.61 inches; temperature, 70° F.

Respectfully submitted,

O. C. HOLLISTER.

SUPREME COURT DECISIONS.

THE following abstract of Supreme Court Decisions is compiled from the "American Digest," and published by permission of the West Publishing Co., of St. Paul, Minn.: —

Where there is a dispute as to the true division line between adjoining proprietors, and they agree on a permanent boundary, and take possession accordingly, the agreement is binding on them, and those claiming under them; and such agreement is not within the statute of frauds. — *Following Jacobs vs. Moseley, 4 S. W. 135; Atchison vs. Pease (Mo.), 10 S. W. 159.*

In ascertaining the boundaries of a city lot bordering on a street, the lines of the street as located by the city engineer, and acquiesced in by the city authorities and the public for many years, are to be preferred to those of a more recent survey. — *Koenigs vs. Jung (Wis.), 40 N. W. 801.*

In taking distances from one point to another on navigable water, the measurement is by its meanders, and not in a direct line. — *Rayburn vs. Winant (Or.), 18 Pac. 588.*

Where there are well-established monuments of a boundary, and the line run from the point of beginning by courses and distance does not conform to one of the natural calls, whereas by starting from the other point, all the natural calls are answered, the first course and distance from the point of beginning must give way, especially when by following it the line is taken out in an open valley where there is no apparent reason for its frequent changes of course, but taken the other way it runs along the base of mountains, which render such changes necessary. — *Hughes vs. Cawthorn, 35 F. 248.*

The Government plat and field notes described the meander line of a tract of land as being at the Missouri River. In fact, the meander line was not run along the river, but along a bayou, some distance from the river; and land between the bayou and the river, though in existence at the time of the survey, had never been surveyed. *Held,* that such land did not pass by a conveyance from the government of the surveyed tract. — *Glenn vs. Jeffrey (Iowa), 39 N. W. 160.*

A patent conveyed the west fraction of a fractional quarter-section containing 23.10 acres. West of such land was a large running slough, or navigable arm of the Mississippi River. In the Government survey of the fractional quarter, a meander line was run along the east bank of the slough, but was not marked on the Government plat. The slough was marked on the map as the west boundary of the land. *Held,* that the meander line was not a boundary, and that the patent included an island lying between

the land described and the middle of the slough, such island never having been surveyed or platted by the general Government. — *Fuller vs. Dauphin (Ill.), 16 N. E. 917.*

A Government "lot" was platted as bounded on the north by a meandered water-course, whose actual shore line was about 320.6 feet north of the meandered line, the lot being merely described as numbered on the plat. *Held*, that its east line ran due north until it intersected the actual shore line, and thence to the middle thread of the stream, at right angles with such thread, and did not turn at its point of intersection with the meander line; the latter line being run, not as a boundary, but merely to determine the number of acres in the lot. — *Menasha Wooden-Ware Co. vs. Lawson (Wis.), 36 N. W. 412.*

Where it appears that a street was originally laid out 23 feet in width, and that it is that width except at the place of plaintiff's alleged encroachment of 23 inches, and that certain trees cut down inside plaintiff's fence were at one time outside a narrow pavement used by the city, and that plaintiff's lot contains all his deed calls for, without said 23 inches, the line as claimed by the city is sufficiently established. — *Yates vs. Town of Warrenton (Va.), 4 S. E. 818.*

Where the dispute is as to whether a certain fence or an adjacent ditch is the division line, it is error to admit the testimony as to what witness supposed, or what was generally supposed, to be the line, though witness had been long and intimately acquainted with the premises. — *Beecher vs. Galvin (Mich.), 39 N. W. 469.*

The statement of a witness that the ditch was acquiesced in as the dividing line between the predecessors in estate of the parties litigant; that it was tacitly consented to by all parties for the reason that no one ever obstructed, or put a fence in the ditch, is inadmissible as being the witness's conclusion. — *Idem.*

A deed conveyed certain lands, "excepting and reserving therefrom 68 feet of land off from the east end of said described premises." The vendor retained possession of a lot 68 feet wide, along the whole east side of the lands, and put the purchaser in possession of the remainder. They built a fence and dug a well on the line thus fixed. The vendor built a house and barn on the portion held by him, and after many years, conveyed it, as 68 feet wide. *Held*, from the acts of the parties, and the surrounding circumstances, that the exception was meant to reserve 68 feet in width along the east end of the lot, and not 68 feet, which would be a strip but six inches wide. — *Montfort vs. Stevens (Mich.), 35 N. W. 827.*

Plaintiff claimed title under a survey by the United States in 1868, and a certificate of purchase from the State describing the

land as in section 18. Defendant showed that the first survey proving incorrect, a new survey was made in 1880, when defendant made a homestead entry upon the land then described as N. W. ¼ section 17. *Held*, that as plaintiff had never been in actual possession of the land, nor had it been listed to the State when he purchased, nor prior to the second survey, the title would follow the second survey. — *Murphy vs. Sumner (Cal.), 16 Pac. 13.*

When, in the description in a deed, reference is made to a plat, it may be used to identify the lands referred to, though it does not conform to the statute, and is not duly certified. — *Sanborn vs. Mueller (Minn.), 35 N. W. 666.*

Where, in an office survey, a line was described as running from a fixed point south to another point described, but not established on the ground, which did not lie in the designated course, it being intended that the line should run north and south, *held*, that the second point named being descriptive, and not locative, should be disregarded, and that the line should follow the course named. — *Lilley vs. Blum (Tex.), 6 S. W. 279.*

In 1847, adjoining lots 51 and 54 were conveyed according to a survey and recorded plat. In 1884, a street having been laid through lot 54, the owner subdivided and recorded a plat of that part of lot 54 between lot 51 and the street, and conveyed the land in question to defendants, who took possession, and in good faith erected buildings thereon. In this survey, a line was established as the true line between lots 51 and 54, as located by the original survey, by following the lines of an old fence shown to have been treated for more than thirty years as the line of the original survey, and regarded as the division line for more than fifteen years, improvements having been made up to this fence. This line corresponded with the fences on adjoining lots, and showed a shortage in the calls and distances of the original plat. Plaintiff's subsequent resurvey started from a line assumed as one of those in the original survey without evidence that it was, and ignoring all fences and following the courses and distances marked on the plat, overlapped the line established by defendant. *Held*, that the line established by defendant must be regarded as the true one. — *Beaubien vs. Kellogg (Mich.), 37 N. W. 691.*

Under How, St., Mich., § 622, providing that county surveyors, in locating extinct interior section corners, shall re-establish them at proportional distances, as recorded in the original field notes, from the nearest known points in the original section lines east and west, north and south, from such extinct corner, a section corner on a town line should be located by lines run from the nearest known Government monuments east and west on the township line, and not by measuring from one known quarter section corner north to one south of the line, and dividing the distance. — *Hess vs. Meyer (Mich.), 41 N. W. 422.*

Under such statute the record of the survey, when made pursuant to its provisions, is receivable in evidence to show the true location of the corners, but the surveyor's work is not *prima facie* correct, and to so instruct is error. — *Idem.*

Though the statutes of Michigan authorize a board of supervisors to direct a surveyor to locate lost corners, and to return his survey, and cause it to be recorded, in which case the record shall be competent evidence to establish the corners, if he makes the survey without causing it to be recorded, it is error to allow the fact of his authority to make it to be proved in a case in which he has testified as to the location of the corners, as the jury might infer that his acts were official, and give his testimony undue weight for that reason. — *Idem.*

In this case, when formerly here, the map of the original survey was not so certified as entitled it to be received in evidence, and there was nothing in the case as then presented that showed that the premises described in the declaration came within the description of the S. E. ¼ of section 28. In the record before us this has been obviated, and the copy of the original plat of the township has been introduced, which shows according to the Government survey that the premises in question are embraced in what the Government denominated the S. E. fractional ¼ of section 28 in its patent to Lingley. It might perhaps have been more accurate to describe it as that portion of section 28 lying south of Black River; but as the fraction contained less than 160 acres, and the law required it to be sold entire, the description contained in the patent was sufficient, and is quite a customary method of description in the General Land Office. The conclusion of law which the court below arrived at — so far as it holds that under the facts of this case as now disclosed, the premises claimed are not contained in the claim embraced in the declaration — is erroneous. — *Wilson vs. Hoffman, 38 N. W. Rep. 558.*

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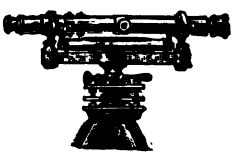

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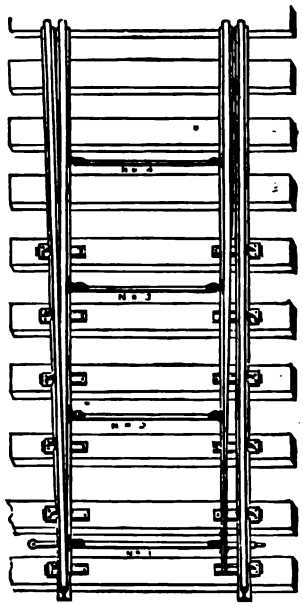

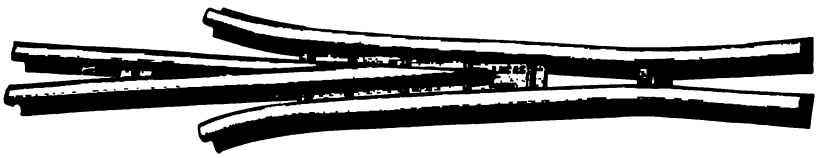

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BIOGRAPHICAL.

PROF. JOSEPH BAKER DAVIS, C. E.

PROF. DAVIS was born in Westport, Massachusetts, in 1845. His father was Ebenezer Davis, a shiprigger, whose skill in his trade was so great that it was said of him that he could plan the rigging of a large vessel so exactly that not a yard of rope would be left over. Mr. Davis's mother died when he was but a few months old, and he was taken to live during his infancy with a Quaker maiden lady, the cousin of his grandfather. This was Miss A. Baker, one of the calm, severe, prudent Quaker type, whose steady character, unswerving devotion to duty, and good deeds, had given her judgment unusual weight in the family. Her influence over Mr. Davis, acquired while he was very young, remained unchanged through her life. After he left home, he kept up a correspondence with her; and when she died, he traveled over a thousand miles to attend her funeral. In her later years, her straight figure, her calm, pure face, her white hair, and her quaint and severe Quaker garb, made her an attractive and striking personage.

Mr. Davis remained with Miss Baker at Westport until he was eight years of age, when he returned to the house of his father, who had in the meantime married again, and was living in New Bedford. His father was also of Quaker tendencies, so that in Mr. Davis's early life there were two especial and interesting features,— Quaker surroundings, and association with persons interested in marine matters. In those days, whale fishing was yet pursued with great activity, and the center of this activity was about southeastern Massachusetts. Whale fishing is a picturesque and fascinating trade, and its influence on the imagination of a young boy must always be notable. Mr. Davis's reminiscences are always full of pictures of whale fishing.

He remained in New Bedford until 1863, when his father purchased a farm a few miles out from New Bedford. From here the father used to go into the city on business, and here young Davis spent the last year with his father's family.

In 1864, he presented himself among the crowd of expectant freshmen asking admission to the University of Michigan. He was admitted, and graduated in the class of 1868, — a class which has left more of its members in the University faculty than any other class ever graduated there. In his University course, Mr. Davis's work was marked by the characteristics which have marked his life since. His sterling manliness and loyalty to his convictions gave him the thorough respect and confidence of his instructors and his classmates. His means were limited, and in addition to the work which he performed with his classmates, he had also to provide for his own subsistence. This he did in

such a way that his standing as a student did not suffer. His sterling ability, his sturdy conscientiousness in his work, and his unremitting industry, overcame all obstacles, and kept him among the first in an unusually strong class. Meantime, in all matters of college or class politics, his fellow students were never in doubt as to where Davis would stand. His strong common sense, with a tincture of Quakerism, was always his guide. His classmates well remember the thickset, strong, good-natured, and fair young man, plainly dressed, unpretentious, hearty in his bearing, and loyal to his class and to his friends. In those closely associated with him at this time, he aroused a feeling of affection which was founded on a basis of respect and confidence. There is no sentiment that is more enduring than an affection founded on such corner-stones. It can only be changed by the conviction that the corner-stones are unsafe. In this case the sentiment has remained unchanged through the quarter of a century which has elapsed since the sturdy young Davis used to occupy the seat of a student.

In the summer of 1867, and therefore while yet a student, Mr. Davis spent a season on Lake Superior, in the employ of the United States Lake Survey. It was while he was here that he laid claim, with what seriousness may be seen by what follows, to a descent from an ancient Welsh family. The chief of the party was, though a civilian, strict in the enforcement of army etiquette, and his assistants, of whom Mr. Davis was one, found themselves treated very formally at the officer's mess. The chief had the lead in conversation at the first dinner table, and he took the opportunity to enlarge on his ancestry, tracing it back that day as far as the Winthrops of Massachusetts. This continued day after day, and those who had been in his party before said it would continue all summer. At last Mr. Davis put an end to it in some such way as this: —

"May I be permitted to make a statement as to my ancestry, Mr. —— ?"

"Certainly."

"You remember that Llewellyn, prince of Wales, applied to Henry III. for protection from his own subjects?"

"Yes."

"It is said that we are descended from Llewellyn!"

The chief stood — or rather sat — aghast. He had been boasting of descent from various provincial governors; but there sat a descendant of the Welsh kings, a relation, consequently, to the reigning English family through the Tudors. The rest of the party did not dare to even smile until out of sight of the chief, but the subject of his ancestry was not discussed further during that summer.

In those days, members of the senior class in the University of Michigan finished their college work at class-day, then a month earlier than commencement. Mr. Davis did not wait during this

month to enjoy his new-found ease, but went at once into the city surveyor's office in Detroit. Office work did not, however, agree with him, and he cheerfully accepted a position which was soon after offered him on the new Kansas, Fort Scott & Gulf Railroad. He went to Kansas, and was occupied there in laying out the road until the autumn of 1869, when he returned to Michigan, and took part in running a new line of railroad near Big Rapids. At the end of this job he returned to New Bedford, and spent a part of the winter of 1869–70 with his father.

In the spring of 1870, De Volson Wood, professor of Civil Engineering at the University of Michigan, wished for assistance in his department, and could find no one more suitable than Mr. Davis. He was consequently made assistant professor at this time, and he has been a teacher of civil engineering ever since. In the following summer he acted as prospector on the Jackson, Lansing & Saginaw road. Before the college year of 1871–72 began, he was offered the professorship of civil engineering at Swarthmore College, near Philadelphia. At the end of this college year his *alma mater* required his services again, and he returned to Ann Arbor, again as assistant professor. Prof. Wood left the University at this time, and was succeeded by Prof. Greene, and the department was re-organized. Mr. Davis has retained his position from 1872 to the present day.

A large part of Mr. Davis's professional activity has been spent in teaching; in fact, with the exception of a year or so, he has been teaching ever since he graduated. During this time, a very large number have passed out from under his instruction to their professional duties. They look back with both respect and affection to their instructor, and with good reason; for, aside from those qualities of head and heart to which I have already referred, and which command these sentiments, he brought to his work as teacher a thorough knowledge of his subject, combined with a conscientiousness and painstaking which would permit no member of his class to slur over his work, or to think himself well prepared when he was not. Mr. Davis insists on as good, accurate, thorough, and honest work on the part of his pupils as he would perform himself, and he often calls their attention to what might be called the ethical side of the profession. Lives and property depend on the honesty and knowledge of the engineer and architect, and an engineer who undertakes work for which he is not competent, betrays the confidence of his employers, and may be punished by law. Thorough and conscientious work must always be done, and this wholesome lesson Mr. Davis especially impresses on his pupils.

In 1872, Mr. Davis married Miss Mary Hubbard Baldwin, daughter of Deacon J. D. Baldwin, one of Ann Arbor's most beautiful and most highly esteemed young ladies. They had been acquainted from the time that Mr. Davis was a student; and the happiness of their life together has been interrupted only by the afflic-

tions which Providence, with a wisdom that surpasses ours, has seen fit to bring on them. They have lost two boys, the eldest and the youngest, and have one living. The living son, Charles, was born in July, 1875. In 1879, they built a pretty and unique house, which they still occupy.

Prof. Davis has written but little; he has been too busy. Nor has he sought honors or employment, but has waited for them to come to him. In addition to his duties as a teacher, he has had as many professional labors as he could attend to. He was made city engineer of Ann Arbor ten or fifteen years ago, without solicitation, and while seven hundred miles away; and, through all the vicissitudes of local politics, he has retained this position. During this time, the appearance of the city has been rendered much better, and many improvements have been introduced. In 1874, he became a junior in the American Society of Civil Engineers, and he remains a junior to this day, probably the junior of the longest standing on the list. In 1883, he was made president of the Michigan Engineering Society, and held the position for three consecutive terms. He has been for a long time a consulting engineer of the Flint & Pere Marquette Railroad, and of the Toledo, Ann Arbor & Northern Railroad. He was for two years vice-president of the "Council of Engineering Societies on National Public Works."

He has interested himself especially in highway bridges, and many of the important ones in the State were built according to his designs. He has also interested himself in city waterworks, and the works of Greenville, Mich., are a standing illustration of the effectiveness, thoroughness, and economy of his plans. He takes, apparently, especial interest in that difficult, time-consuming, and exasperating duty of surveyors, — that of finding missing corners, — and to this he brings to bear an amount of tact and experience rarely found elsewhere, and a willingness to expend more labor than most surveyors are willing to put on it. The result is that with him the lost corners are always found, and with the finding of them comes the definite and authentic settlement of boundaries so necessary to the comfort of land owners.

M. W. HARRINGTON.

BUSINESS TRANSACTIONS

OF THE

MICHIGAN ENGINEERING SOCIETY

For the Year 1888–89.

MEETING OF BOARD OF DIRECTORS.

THE annual meeting of the Board of Directors was held at the Hudson House, Lansing, Oct. 10, 1889. There were present President Geo. E. Steele, Secretary F. Hodgman, and Directors Appleton and Cooley. The meeting was called to order, and the report of the Secretary was read and approved, as follows: —

REPORT OF SECRETARY.

Your Secretary would respectfully report that he has transacted the following business for the Society since the Annual Convention: A contract was made with Ihling Bros. and Everard to publish the Ninth Annual Report, 1,000 copies, for $242, cuts and extra work above that called for in the bid to be paid for by the Society. The publication was greatly delayed by various causes, but was well done, and a very satisfactory job. Ballots for new members were sent out early in the season, and the several applicants duly elected to membership. Ballots for officers were also sent out, and those returned are herewith submitted for canvassing.

Circulars relative to manner of sending out the reports, and also relative to subjects for discussion at the next Convention, were also sent to all the members, and answers received which are submitted to the Board.

The cash account of the Society stands as follows: —

On hand Jan. 17, 1888	$185.41	
Received for fees and dues to Oct. 10, 1888	247.00	
Interest on Strudwick note	6.25	
From Heller and Brightly	9.65	
From reports sold	5.00	
Total		$582.31

Paid John Eisenmann special fund Nat. Pub. Works	$ 42.00	
Secretary's salary	50.00	
Expenses of Executive Committee and Board of Directors	40.40	
Stenographer	16.00	
Returned F. E. Kirby overpayment	14.00	
Janitor at Kalamazoo	6.00	
Secretary's expenses getting out reports	15.60	
Express charges on reports and cuts	17.55	
Publishing Proceedings	208.84	
Postage and other incidental expenses	62.07	
Balance on hand Oct. 10, 1888	109.85	
Total		$582.31

The Society owes Ihling Bros. and Everard for printing Proceedings, Circulars, etc., $92.04. There is due the Society from advertisers, $40, leaving the financial standing of the Society as follows: —

Cash on hand	$109.85
Bills receivable	40.00
Total	$149.85
Bills payable	92.04
Balance	$57.81

I have recently received notice from Mr. Wright, of Bad Axe, to the effect that the property of Mr. Strudwick was to be sold on a mortgage, and asking further instruction in regard to the collection of the note in his hands. I replied to him that if Mr. Strudwick was as hard up as that, to give him the note. The Society did not care to crowd him under such circumstances.

F. HODGMAN, *Secretary.*

The Board then proceeded to canvass the ballots for officers of the Society for the ensuing year. For President, there were 58 votes cast, of which Geo. E. Steele received 36, J. B. Davis 14, and A. L. Reed 8.

For Vice-President, there were 54 votes cast, of which Joseph Ripley received 42 votes, and E. F. Guild 12.

For Secretary, 54 votes were cast for F. Hodgman.

For Treasurer, 55 votes were cast for Geo. S. Pierson.

For Directors, M. E. Cooley received 48 votes, Wm. Appleton 30, A. J. Teed 17, A. L. Drew 14, J. H. Forster 6, and E. Dennis 4.

The following persons were then declared duly elected for the term beginning Oct. 10, 1888: —

President, Geo. E. Steele.

Vice-President, Joseph Ripley.

Secretary, F. Hodgman.

Treasurer, Geo. S. Pierson.

Directors, M. E. Cooley and Wm. Appleton.

Bills of members of the Board of Directors for expenses in attending this meeting were audited and allowed as follows: —

Geo. E. Steele, $15.35; F. Hodgman, $5.00; M. E. Cooley, $3.80.

On motion of F. Hodgman, it was voted to hold the next Convention at Lansing, beginning Jan. 22, 1889.

Prof. R. C. Carpenter was appointed a committee to provide for a paper on the uses of Photography in Engineering and Surveying, and for a stereoptican exhibition in connection therewith.

The Secretary presented a list of topics for discussion at the next Convention, returned by the members of the Society in response to his circular, also a list of names of those who had consented to prepare papers. Several topics were added to the list, and names of persons selected to be invited to prepare papers on these topics. Prof. M. E. Cooley was appointed a committee to present to the Society the matter of representation in the Council of Engineering Societies. The meeting of the Board was then adjourned.

F. HODGMAN, *Secretary.*

ANNUAL CONVENTION.

THE Annual Convention was held in the Pioneer Rooms of the State Capitol, commencing Tuesday, P. M., Jan. 22, 1889.

The Convention was called to order by the President at 2 P. M., and the programme read. The Secretary's report was read and accepted, and referred to a committee consisting of J. J. Watkins, J. H. Forster, and R. C. Carpenter. The report is as follows: —

SECRETARY'S REPORT.

ARTICLE II. Section 5 of the Constitution requires the officers of the Society to report at the annual meeting all business transacted by them for the Society. As Secretary, I deem it proper to report also to the members present at the Annual Convention, adding such suggestions as the experience of the past year seems to call for.

At the close of the last Convention, the first business transacted was the preparation of the annual proceedings. Bids for the publication were received from the Kalamazoo Publishing Co., the Review & Herald Publishing Co., and Ihling Bros. and Everard. The contract was awarded to the latter company, they having made the lowest bid. Considerable time was spent in securing advertisements, a work of no little labor and trouble. I here venture the hope that in future each member of the Society will feel it both a duty and a privilege to assist the Secretary in this work, and that the feeling will be strong enough to induce action. The copy for the proceedings was furnished the publishers about the first of March. In order to avoid as far as possible all errors in printing

of the papers, revised proofs were sent to the authors for final correction. Some of the authors were slow in returning them, thereby causing much delay. Various other causes beyond my power to remedy conspired to delay the publication, which finally came to me three months behind the time agreed on. This was a source of infinite annoyance to me. I hope to avoid a recurrence of the difficulty, but my experience with the ways of the printer is not re-assuring. I held the reports a few weeks before sending them out, in order to have as many of the exchanges as possible to send with them, and make a single job of it. I regret to say that the state of the mail service was such that numerous complaints of the non-receipt of reports came to me from the members of the Society and the press. I sent copies to every member, and sent out duplicates as long as I had any left to send, but I fear there are still members minus the reports they should have. Exchanges were made with the societies of Arkansas, Indiana, Ohio, Illinois, Iowa, University of Michigan, Dominion and Provincial Land Surveyors of Canada.

No reports have been received from Missouri since 1886, and at the last account I had, they were not published.

Right here I wish to speak of the manner of sending out the reports. In Ohio, the Secretary writes me that the reports are held till all the exchanges are received, and all are sent out together at the members' expense, by express. Thus far we have sent them out at the Society's expense, but it is becoming a question of money with us. In future, we must have increased revenues or decreased expenses. Increased revenues may be had by additions to our membership, by increased advertising patronage, or by increased annual dues. To secure increased membership and increased advertising patronage, the hearty co-operation of every member of the Society is required. Heretofore not more than four or five members have done anything to assist the Secretary in securing advertising, and it is no slight burden to carry alone. As to dues, it may be said that they are very low. The Ohio Society collects its revenues by annual assessments, and they are rarely below $3.00.

Expenses may be reduced by cutting off our exchanges, publishing fewer reports, and getting them up in cheaper style. They may also be reduced by the Secretary's using less stationery and postage stamps. During the past year, aside from the circulars sent out which the members know all about, he has had more or less personal correspondence with nearly every member of the Society, and has written to every surveyor in the State, whose address he could procure, in furtherance of the objects of the Society. Much of this might have been left undone at a saving of stationery and stamps, but I believe in the long run it will pay a big interest in the investment. And right here I ask it as a personal favor that each member of the Society will furnish me with a list of every

surveyor, civil engineer, and engineering student in the State, of their acquaintance outside of the Society, with their addresses. Will you do it for the benefit of the Society?

We have received from Prof. J. B. Johnson, of St. Louis, a copy of his work on surveying, and from Geo. S. Pierson, a copy of his work on sewerage. The Secretary suggests that we should formally express our appreciation of the courtesy of these gentlemen, in donating these valuable books. The University of California has furnished its publications for the past year, in exchange for our Annual Report. We have also received the *Railroad and Engineering Journal* for the year by a similar exchange. An arrangement was made with the *Engineering News*, *American Engineer*, and *Scientific American*, by which these journals were furnished the Society the past year in exchange for short advertisements in the proceedings. These journals all rank with the best in their respective lines. I would specially mention the *Railroad and Engineering Journal* and *Engineering News*, and commend them to your good will. The latter has uniformly assisted the Society with its influence and advertising patronage, and should receive a generous response in the way of subscriptions from us.

Among our exchanges the past year was the *Technic*, published by the Engineering Society of the University of Michigan. In it we got a portrait of the first President of our Society, Prof. C. E. Greene. Many of our members would be very glad to secure a portrait of our second President, Prof. J. B. Davis, and I would suggest that measures be taken to secure it for the 1889 reports.

BALLOTS.

Letter ballots for new members and for officers were sent out in due season. None of the candidates for membership were rejected. The result of the vote for officers was duly announced by circular to every member. It strikes the Secretary that it would be well for every member to read the instructions on the letter ballot before voting, especially where there are several candidates for the same office. The ballots for officers were found in all variety of shapes. Some members even went so far as to write on the ballot for officers that they had no objections to any of the candidates, and so voted for them all. If their intentions had been carried out, we should have had two more presidents than our laws allow, to say nothing of other extras.

AMENDMENTS.

In this connection I suggest that it is probable that in the haste attending the adoption and engrossing of our Articles of Association, Constitution, and By-Laws, that they were not in all cases left in the form intended by the incorporators or desired by the later members. It is doubtful if the Board of Directors is constituted as the Society designed it should be. The By-Laws also

need a careful revision to make them harmonize with themselves, and fully express what the Society designed to adopt. If necessary, amended Articles of Association should be filed with the Secretary of State, and a committee appointed to revise the By-Laws, and submit them as revised to the Society by letter ballot.

SUBJECTS FOR PAPERS.

It would be a great assistance to the officers of the Society if every member would suggest a topic which he would like to have discussed in the Convention, and assist in getting the best man to present it. There is no danger of having too many. The more we have, the better the Directors can make good selections for a first-class programme. There are some members who can always be relied on when called on to come to the assistance of the officers in every endeavor to promote the welfare of the Society, whether to suggest topics or prepare papers, to bring in new members, or solicit advertising patronage. There are others who can equally be relied on either to make no response to an appeal for assistance, or else curtly reply that they "have no time to spend for such things." It is not necessary to express any opinion in regard to these two classes, but the Secretary has one clearly defined in his own mind, and he appeals to every member to do whatever he can to bring and keep the Michigan Engineering Society up to the best possible standing. Let us have live, active, aggressive members, without one on the list who is nothing but an absorbent. We now number 105 members, with several applications to be voted on by letter ballot. We ought to have more than twice that number, and will have, if every member does his duty.

Let us bring in the bright, zealous, active young men from the schools, and the clear-headed, brainy working-men from the profession, but do not ask a sponge or a dead-head to join the Society. Live, active men are willing to come here and exchange thought for thought and idea for idea, but they are not willing to sell the work of their brains and the fruit of their experience for two dollars a year, to be paid the Society as dues.

LAND LAWS AND DECISIONS.

I congratulate the Society on the fact that the work done by it in collecting land laws and decisions is having its effect. In evidence of it, I call attention to a recent decision of our Supreme Court on a second trial of the Wilson *vs.* Hoffman case. The doctrine was laid down in the first trial of the case, that a fractional lot cannot extend beyond a quarter line. This was re-affirmed in Keyser *vs.* Sutherland and Palmer *vs.* Dodd. The Supreme Court, of their own motion, ordered a rehearing of the Wilson *vs.* Hoffman case; and in the second trial of the case, the language of the decision clearly shows that the authorities cited and the arguments presented in the papers read before this Society, have induced the

Court to break away from an established line of precedents, and reverse their former decision in the case. All honor to them for it. We may now expect that other errors will be corrected when cases come properly before them for consideration.

We now have no committee on this or any other branch of our work. I recently wrote to the great law publishing firm of West & Co., St. Paul, who publish the *Northwestern* and other reporters, asking them if they would furnish us with sheets from their publications containing reports of cases of interest to us, for binding with our annual reports, and also if they could themselves, at the end of each year, furnish us with a volume containing that class of cases decided during the year, and if so, at what cost. They replied that for reasons which they gave, it was not practicable for them to do either, but that they could put us in a way to get what we desired. They publish a monthly Digest, containing the syllabi of all decisions reported for the month, throughout the United States. From this we could cull whatever we wanted. If any case seemed of sufficient importance to warrant it, we could get the full text of the decision for twenty-five cents. We can have the privilege of publishing in our proceedings by giving proper credit. The Digest, of which I have samples, will cost us $5.00 per year; and I favor subscribing for it, as a most valuable addition to our means of information.

REPORT OF SPECIAL COMMITTEE IN SECRETARY'S REPORT.

The committee to whom it was referred, reported as follows, and the committee's report was accepted and adopted, except the parts relating to changes in the Constitution and By-Laws, which could not be adopted at this meeting.

To the Members of the Michigan Engineering Society:—

GENTLEMEN: Your committee to whom was referred that portion of the Secretary's report recommending some changes in our Articles of Association and By-Laws, desire to report it advisable to change the reading of Article III. of Articles of Association, so as to read as follows: —

"The officers of this Association shall be one President, one Vice-President, one Secretary, and one Treasurer, which last two named offices *may* be filled by one person, and a Board of five Directors, two of whom shall be the President and the Secretary.

"The annual meeting of this Association shall be held on the second Wednesday in October, at Lansing."

That Article III. of the By-Laws be amended by striking out the word "membership," and inserting after the word "fee" the words "of three dollars."

That Article V. be amended to read as follows: —

"On being elected, the applicant shall sign the Constitution and By-Laws (unless when for removal and having signed a copy of the

same transmitted to him by the Secretary, the Secretary may enter his name to the list of members as having signed), and shall pay into the treasury an initiation fee of three dollars, and when admitted as a senior member the further sum of two dollars, after which payment or payments, he shall receive a certificate of membership. If said initiation be not paid within thirty days from notice of election, said election shall be void."

That Article VI. be amended to read : —

"Every person admitted into membership of this Society shall be liable for the payment of his assessments so long as the Society shall retain his membership ; but after payment of all dues, at his request he may be released from his connection by a vote of the Society at its annual Convention. Any member neglecting or refusing to pay any assessment for three months after due notice by mail, may at the option of the Society be declared as having forfeited his membership.

In reference to sending out reports, we would recommend that the reports of our proceedings be forwarded by mail to each member not in arrears for dues or assessments, and that our exchange reports be forwarded by express at the expense of the individual members.

That it shall be the Secretary's duty in behalf of the Society to courteously acknowledge the receipt of all books, maps, and other matter donated to the Society, and any omission that may have occurred in suitable recognition be corrected at his earliest convenience.

It is also recommended that this Society procure the "American Digest," and that the Secretary be the Committee to procure such Digest and make selections therefrom touching all important matter necessary for our vocation to be printed in our report.

It is recommended that our President address a letter to our last past President, soliciting him to furnish the Secretary with a likeness of himself, to be included in our next annual report.

Respectfully submitted,

JOHN I. WATKINS,
JOHN H. FORSTER, } *Committee.*
R. C. CARPENTER,

REPORT OF SPECIAL COMMITTEE ON COUNCIL OF ENGINEERING SOCIETIES.

Prof. M. E. Cooley, who was appointed by the Board of Directors a committee to consider the relation of this Society to the Council of Engineering Societies, reported the work being done by the Council as in a favorable condition, with a fair prospect of the attainment of its chief object, the establishment of a National Board of Public Works, and recommending that the Society place itself in a position to co-operate with the Council. The report was accepted, and it was voted that a committee be appointed, consisting of Prof. J. B. Davis as Chairman, and the Board of

Directors to take such action relative to the work of the Council of Engineering Societies as they may deem for the best interest of the Michigan Engineering Society. The committee furnishes for the information of the Society details of the present condition of the work of the Council of Engineering Societies from which the following items are condensed.

The House Committee on expenditures in the War Department on the 19th of February, 1889, reported to the House a bill which provides for the establishment of a Bureau under the War Department to be known as the Bureau of Harbors and Water-Ways, to be officered by a corps of United States Civil Engineers. The organization, duties, pay, etc., of this corps is provided for in the bill, and all engineering works of a civil character carried on by the Government are placed under their direction. The bill was carefully drawn after a very full discussion of the various points, and meets the views of eminent civil engineers who have been interested in the matter. The following extracts from the report of the House Committee partially presents their views in regard to the proposed change: —

"In the opinion of the committee, the time has come to inaugurate a definite policy in regard to national public works, and to provide a specific agency for its execution. The sense of the people and of Congress has shown a steady growth for twenty years in favor of the development of harbors and water-ways. During this time grave objections have been urged against legislative and administrative methods, and these objections have gathered force with each passing year, until the enactment of a river and harbor bill is uncertain and occasional, instead of being regular and the best approved legislation, as it should be.

"In legislation, it is charged that Congress is not appropriating in harmony with any well-conceived general plan or system; that each work is largely considered as a detached or individual work, without special regard to any other or to any collection or group of works as a whole; that appropriations are uncertain and inadequate for economical results, and often for any results at all; and that the largest and most important national works fail to receive that attention which is indispensable if they are ever to be completed.

"In administration, various objections are urged which are largely incidental to the necessary method of organization of a military body, and that are not adapted to a strictly civil work and function. Upon some important public works, Congress has thought it judicious to provide irregular mixed commissions. A necessary and the larger part of the technical force is without proper recognition, tenure of position, or hope of advancement, resulting in constant change in *personnel* as some experience is acquired. The military system does not readily adapt itself to the best civil practice, nor is it desirable that it should, if the corps is

to remain a part of the army. It is unnecessary to more than refer to this phase of the question, as the passage of the bill is urged largely on other grounds.

"The truth of these allegations, to a greater or less degree, is acknowledged by every one. They can be indefinitely multiplied and expanded, and have been ably presented to your committee. Great good would come by changing the legislative practice, likewise, by a specific adaptation of the administrative organization to its work. These changes should, however, be complementary for the best result. What this result should be, may be best indicated by the history of recent appropriations.

"Since 1880 we have had appropriations practically every other year, uncertain in amount, uncertain as to passage, and, in detail, an uncertain fraction of the estimate for each work. Every one will admit that the results obtained have been in many cases very meager. Every one will admit that, had the same total been appropriated in regular sums year by year, far more would have been accomplished. It will probably be conceded that could the money be applied in the best manner in accordance with some rational system, far greater results could be had. In other words, we fall far short of accomplishing what we should do under a proper system.

"Mere changes in the methods of making appropriations, or in the administrative system, or both, will not be sufficient. The evil is fundamental, and requires a radical change. Congress, for some reason, has taken upon itself functions which in other countries, more advanced in these works than ours, are performed by a board of public works, a board composed of technical experts who have made the possibilities and the needs of their country a life study.

"In carrying the law into effect, your committee does not see that the progress of public works need be hindered or stopped. The change can be brought about in such a manner as to produce no break in the continuity of operations.

"When we consider the enormous total required to complete the works now projected, and the inadequacy of the appropriations when compared to the annual estimates, we fully believe that under the system proposed, the completion of these works will be greatly hastened, at less expense, and on plans better considered in reference to the needs of the country and the future possibilities of a water-way system."

The following extracts from a letter accompanying Prof. Cooley's report shows further the condition of the work and the relation of the Michigan Engineering Society to it.

ANN ARBOR, Jan. 22, 1889.

Prof. M. E. Cooley:—

MY DEAR SIR: In answer to your inquiry concerning the Council of Engineering Societies, organized three years ago for the organization of national public works in the United States, and

the relations of the Michigan Engineering Society in regard thereto, I can offer you a few facts and suggestions:

The Michigan Engineering Society, for a time, took an active part in perfecting the organization of the Engineering Societies. Our Society was honored by its part in the matter, and your humble servant, because of being its representative, was placed in responsible and honorable positions in that work. At our Grand Rapids Convention, I think it was, our Society discharged its committee, and severed its connection with the movement, at a time when its aid was much needed and when results were being reached. I am sure our Society ought to take part in this national effort of our profession to do what it can to improve this branch of service, and to make it a civil service of efficiency. I hope our associates will enter again upon this work with earnestness and devotion. I believe the day will come when they will not want to be left out. Michigan cannot afford to be left out. About 10 per cent of the River and Harbor money is spent on the lakes. Michigan gets much of, if not the most of, that 10 per cent.

This State needs well-made and well-expended appropriations if any State does. With a coast exceeding the whole Atlantic east front, and with a coast-wise commerce exceeding that of the whole Atlantic coast, I believe I may be pardoned for thinking that our State has an interest in every improvement that can be made in the method of our public works. When one reflects that our Sault Ste. Marie Ship Canal (the first in the United States) carries a tonnage to-day equal to, if not greater than, does the Suez Ship Canal that is justly regarded as a highway of the nations, it is conceivable, I think, that one might consistently believe that Michigan has interests at stake in the national conduct of public works for bettering navigation. And I do n't believe our engineers are careless of these interests. They simply do n't realize the case. Now the case is just this : —

1. We have no system of public works.
2. We never did have.
3. We pride ourselves on being free people, governing ourselves, administering our own affairs.
4. Internal improvements are civil public works, not military.
5. What money is spent in this line at present is disbursed by the army.
6. Germany, France, Italy, and Great Britain have such work done by civilians. In fact, the more military the nation, the more perfectly is this work organized on a civil basis.
7. Should our public works be civil or military in character in comparison ?
8. These great nations have a system ; we do not.
9. The civil engineers of this country, from the Atlantic to the Pacific, and from Lake Superior to the Gulf of Mexico, have

organized to do what can be done to get a system, and an edequate one.

10. Much has been done. The work is in good shape, thanks to the President and his associates, of which I do not hesitate to speak, as I have held no official connection with them for about two years. What has been done you can see from the printed matter herewith.

11. This work is to go on, I believe, to a successful issue.

12. There is opposition; but not on the principle. There can be none. The opposition, so far as it is manifest to me, is specious, local, or selfish, or tries to be, not knowing where true self-interest lies.

13. This movement is past the polyp, jelly-fish stage. It walks. It has friends. It has enemies. It is sound and healthy.

14. It requires men, money, thought, study, effort, and counsel to carry it on.

I cannot condense the case into a sentence beyond saying, We, as a nation, have *drifted* in this matter; there are defects and abuses in consequence; it is time to man the sails, take the helm, and steer.

I wish the Michigan Engineering Society might feel it a duty to bear a hand.

Cordially yours, and theirs,

J. B. DAVIS.

APPLICATION FOR MEMBERSHIP.

The following applications for membership were passed upon by the Board of Directors, and approved for Senior Members: —

Brown, F. H., Surveyor, Sault Ste. Marie, Mich.; Baldwin, Willis, Surveyor, Monroe, Mich.; Coryell, R. J., Surveyor, Jonesville, Mich.; Campau, Thomas, Surveyor, Detroit, Mich.; Cox, George, Civil Engineer, Sault Ste. Marie, Mich.; Davis, Geo. L., Civil Engineer, Cadillac, Mich.; Davis, L. M., Civil Engineer, Gladstone, Mich.; Douglass, Benj., Civil Engineer, Detroit, Mich.; French, Edgar, Civil Engineer, Battle Creek, Mich.; Gifford, Jas. M., Surveyor, Duck Lake, Mich.; Hayes, Eli L., Surveyor and Map Publisher, Reed City, Mich.; Jones, E. H., Surveyor, Greenville, Mich.; Kedzie, Frank S., Chemist, Agricultural College, Lansing, Mich.; Merritt, R. B., Surveyor, Battle Creek, Mich.; Mc Loughlin, John, Civil Engineer, Detroit, Mich.; Mahon, Wm. L., Mechanical Engineer, Detroit, Mich.; Pelham, Fred B., Civil Engineer, Detroit, Mich.; Roehm, George E., Civil Engineer, Detroit, Mich.; Smith, Stewart K., Civil Engineer, Somerset, Mich.; Shenehon, Frank C., Civil Engineer, Sault Ste. Marie, Mich.; Sowter, I. G., Mechanical Engineer, Detroit, Mich.; Todd, O. H., Surveyor, Nottawa, Mich.; Van Culebroeck, A., Boiler Maker, Lansing, Mich.

NOMINATIONS FOR OFFICERS.

The following names were placed in nomination for officers of the Society for the ensuing year, to be voted on by letter ballot: —

For President: R. C. Carpenter, A. L. Reed, Joseph Ripley, I. H. Leavenworth.

For Vice-President: J. H. Forster, John J. Granville, John J. Watkins.

For Secretary and Treasurer: F. Hodgman.

For Directors: Geo. E. Steele, A. J. Teed, M. E. Cooley, Frank F. Rogers, Chas. E. Greene, Seth N. Beden.

On motion of F. Hodgman, it was voted that the Board of Directors be authorized and directed to file in the office of the Secretary of State, Amendments to the third Article of the Articles of Association, providing that the Board of Directors shall consist of five members, two of whom shall be the President and Secretary, and that the remaining three members shall hold office for the term of three years each, one member to be elected each year, except that at the next election one Director shall be elected for one year, one for two years, and one for three years.

On motion of Prof. Carpenter, it was voted to pay the Secretary $50 for the past year's services.

Mr. McLoughlin, of the committee to whom was referred the President's Address, made a report commending the address, and recommending that the professors in our State institutions of learning be requested to cause to be furnished to the public, through the press, such matters of interest to engineers as may be brought out by their investigations; and further recommending, that committees of one member each be appointed to consider and bring before the Society matters of interest on the following topics: —

1. Questions of practice.
2. Court decisions.
3. Photography.
4. Standard specifications for block pavement.
5. Standard specifications for pipe sewers.

The report was adopted.

On the suggestion of Prof. Cooley, it was decided informally to defray the expense of the portrait of Prof. Davis, by contributions from the members.

Detroit was chosen as the place for the next meeting.

The Convention was closed with a fine exhibition of stereoptican views by Profs. Frank S. Kedzie and R. C. Carpenter, of the Agricultural College.

ATTENTION!

THE Secretary desires to call attention to the advertising columns of the Annual. The firms there represented are all worthy of our patronage, and should receive it. In view of the progress of photography as applied to engineering science, the advertisements in that line are of special interest. The portrait of Prof. Davis furnished the Society with this number of the Annual, is from the Eastman Dry Plate and Film Company, whose advertisement will be found in these columns.

ERRATUM.

IN the "Proceedings of the Michigan Engineering Society for 1888," on page 139, twelfth and thirteenth lines, for "above zero in ascending a grade line, or below zero in descending it," read "BELOW zero in ascending a grade line, or ABOVE zero in descending it."

OFFICERS FOR 1889.

President — GEORGE E. STEELE, Traverse City, Mich.

Vice-President — JOSEPH RIPLEY, Detroit, Mich.

Secretary — FRANCIS HODGMAN, Climax, Mich.

Treasurer — GEORGE S. PIERSON, Kalamazoo, Mich.

Directors — M. E. COOLEY, Ann Arbor, Mich.; WM. APPLETON, Lansing, Mich.; and the President, Secretary, and Treasurer, *ex officio*.

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BECKMANN, L., Manufacturer Surveying Instruments, Toledo, Ohio.

BEDEN, SETH N., Surveyor and Civil Engineer, Pine Run, Genesee Co., Mich.

BELLOWS, C. F. R., Prof. Math., Mich. State Normal School, Ypsilanti, Washtenaw Co., Mich.

BLAIR, JAMES, Surveyor and Drainage Engineer, Morenci, Lenawee Co., Mich.

BEAN, HENRY F., Civil Engineer, Jackson, Jackson Co., Mich.

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COOLEY, M. E., Prof. Mech. Eng., Univ. of Mich., Ann Arbor, Washtenaw Co., Mich.

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CARPENTER, L. G., Prof. Eng. State Ag'l. College, Fort Collins, Colo.

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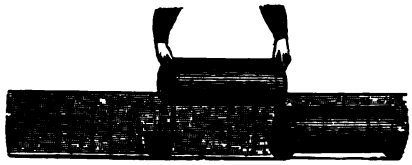

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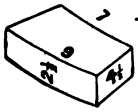

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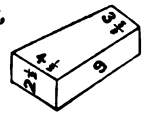

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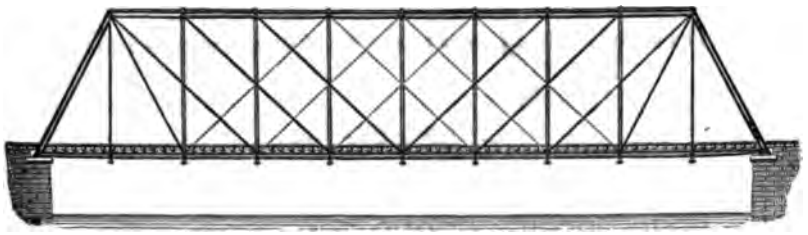

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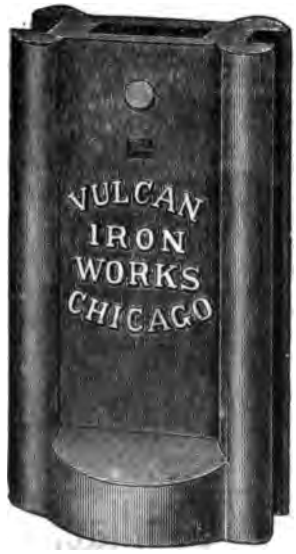

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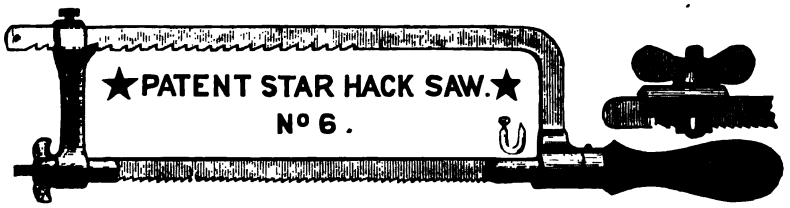

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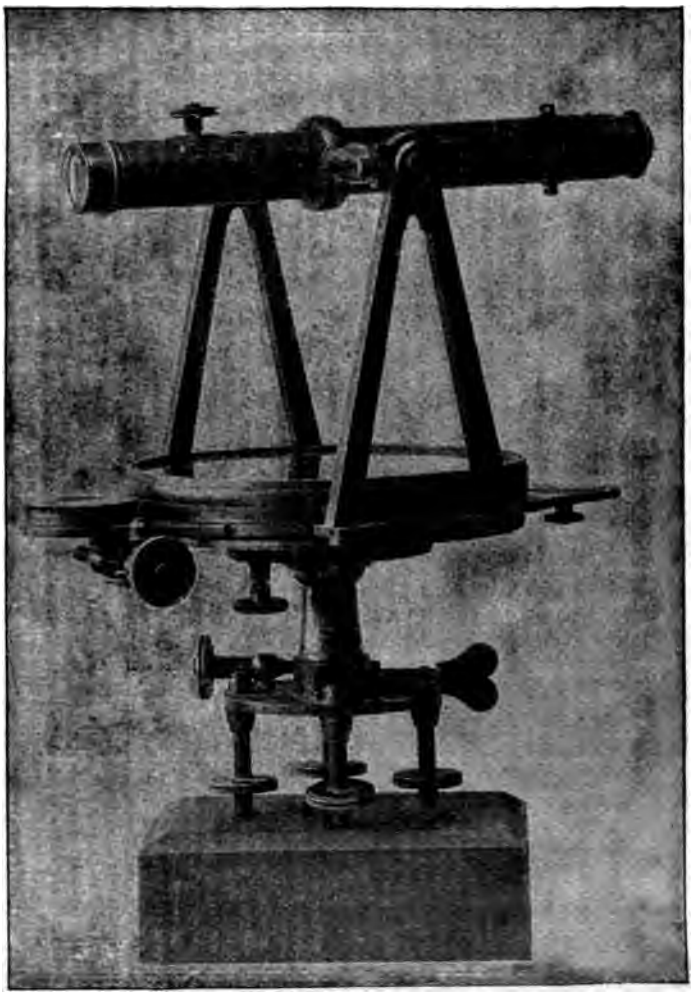

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FOR 1890

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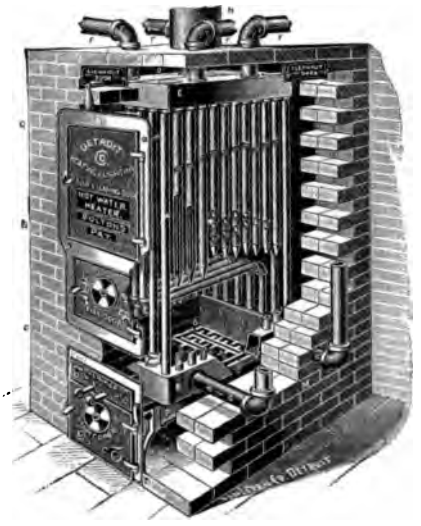

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Yours, &c., J. L. WELLS.

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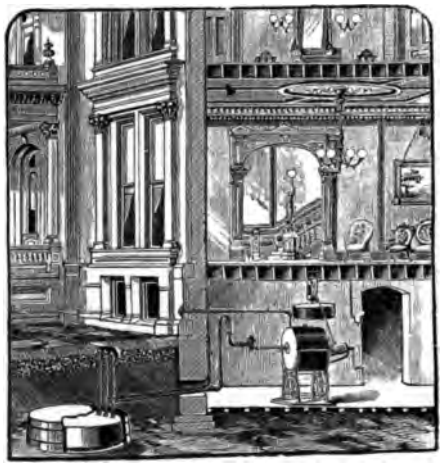

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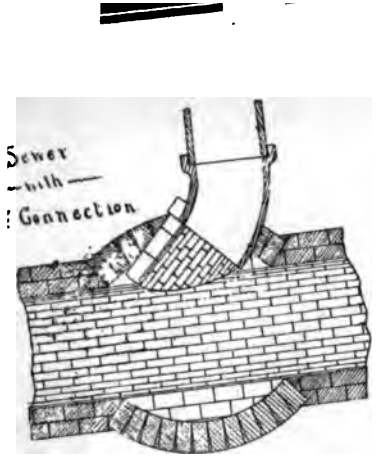
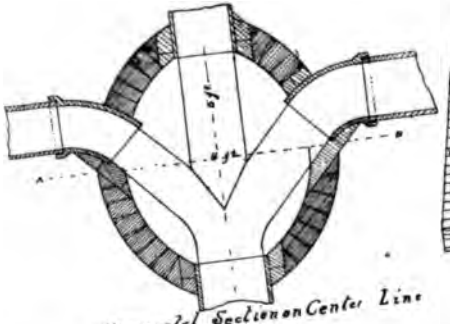


Horizontal Section on Center Line of Sewer

MANHOLE "B"



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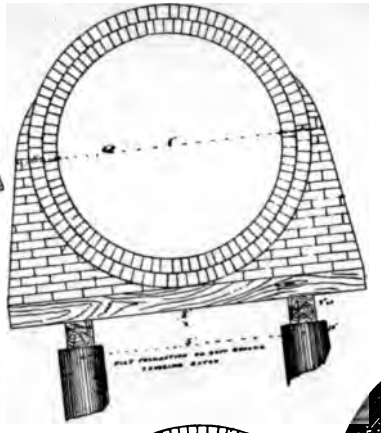
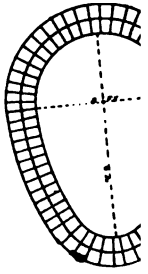
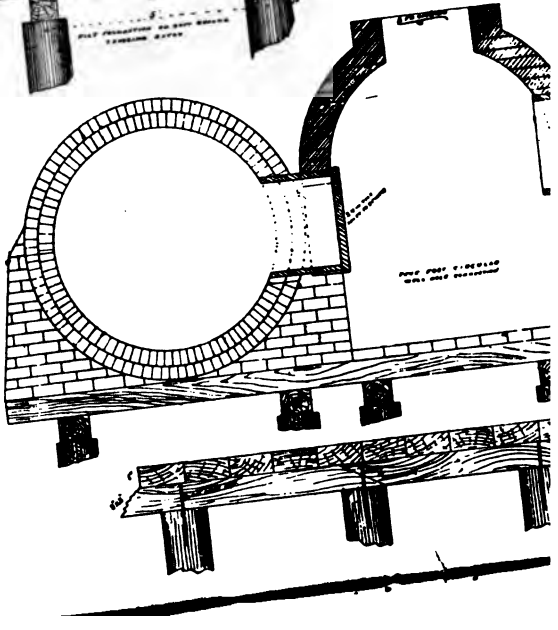
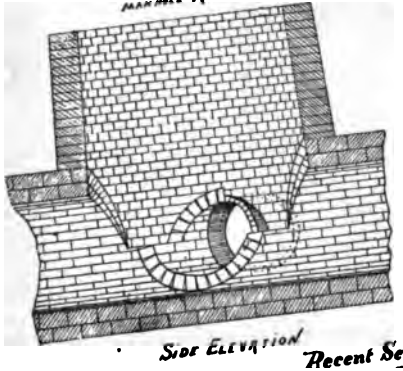






MANHOLE "A"



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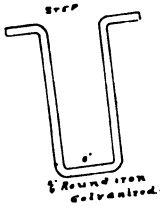

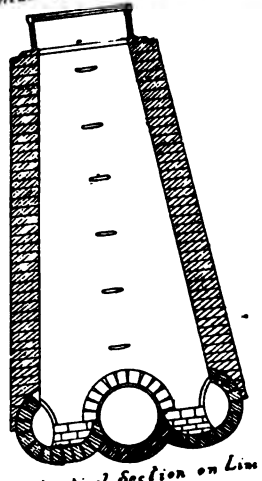

Vertical Section on Line 'A B'

Recent Sewer Construction
BAY CITY MICH.

MICHIGAN ENGINEERING SOCIETY.

Papers and Discussions at the Eleventh Annual Convention, held at Detroit, January 21-23, 1890.

SEWERAGE OF WEST BAY CITY.

DURING the years 1888-89, a system of sewers was designed and constructed by the Board of Public Works, a short description of the same being attached.

The outlet is into the Saginaw River, and lying back from the river is a low, marshy tract of ground running parallel to and about two thousand feet from it. Between this bayou and the river is a sand ridge upon which the business part of the town stands. The principal object sought after was to drain the bayou and in connection therewith to establish a system that would meet the requirements of drainage for all time to come. The Board of Public Works divided the city into districts and made plans for a main sewer.

The main sewer is constructed of double rings of brick, and all district and lateral sewers of socket tile. The outlet is a box 5x5 feet inside, made of 6x6 inch Norway drift, bolted together with a 4 inch top and bottom spiked to the sides. The box is about 175 feet long, and at the lower end the bottom is 18 inches under ordinary water level. When solid ground was found, the brick-work was started and excavations made, by the use of pumps in keeping out the water, as the bottom was below the surface of the river, and the soil sharp sand. A wood invert was provided to shape the sides and bottom of the trench, and the brick laid thereon for a distance of about 600 feet, when clay was found of sufficient hardness to be shaped by lines and templets to receive the brick. The sewer from the river to the bayou is 5 feet inside, round, a distance of 3000 feet, built on a grade of 1 foot in 2000 feet. In this distance there are two curves of 80 foot radius and there

is practically no change in the velocity around them. At the bayou there was no bottom solid enough to build on, and piles were driven 24 feet, sawed off and timbers laid thereon for a foundation. After intersecting the bayou, the size and shape was changed from round to egg shape, 36x54 inches, and this size continued on a grade of 1 foot in 1000 a distance of 2900 feet, where, after making another angle and crossing the bayou a second time, the size was again reduced to 28x42 inches which size was continued 2500 feet. The average depth of the large sized sewer was 19 feet; in some places being as deep as 23 feet and in sand. Manholes are built at intervals of about 300 feet, or at every crossing.

The main district sewers will be 18 inches in diameter with 12 inch laterals and 6 inch house connections, and will be on a grade of from 1 foot to 3 in 100, which I think will be sufficient to be self-cleansing.

The brick were hard burned and tested for lime, etc., by being immersed in water until thoroughly wet, and then laid by experienced men with Buffalo cement and sharp sand in proportion of 1 to 2.

The entire cost of main sewer was about $50,000.00, for which bonds of the city were issued.

H. C. THOMPSON,
City Engineer, in charge of Sewer Construction.

SURVEYS MADE

— FOR —

Railroads, Water Supply, Sewerage

AND MUNICIPAL PUBLIC WORKS.

H. C. THOMPSON,

Civil Engineer and Surveyor. County Drain Commissioner.

WEST BAY CITY, MICHIGAN.

PERSONAL REMINISCENCES OF RANDOLPH NUTTING.

SOMETHING like twenty years ago, the Highway Commissioner of Pavilion, Kalamazoo County, Michigan, came to me to get me to survey the line of a highway that they wished to lay out in that township. The man said:—

"We have been in the habit of employing Randolph Nutting to do our surveying in that part of the county, and I have had him at work on this job for a week, without accomplishing anything. I can't stand it any longer and I wish you would go and run out the line."

"What is the matter with it?"

"Oh, nothing, only old Randolph has got cracked on religion. He always was a little off in the upper story, and now he is worse than ever. I got him out to run the line, and the first thing he did was to get down on his knees in the dirt and pray. Then he measured his chain to see if that was right and then he prayed again."

"What did he measure his chain with?"

"Oh, with a two foot-square. Then he went to get a corner to work from, and he spent the whole day digging and praying and puttering around that corner. Next day he began to run the line, but he had not gone more than forty rods when he had to get down and pray again and then go back and measure it over. Then he was dissatisfied with the starting point, and went back and fussed and dug and prayed over that, and so he kept going for a week."

I found it about an hour's work when I got there. It was not the first time I had heard of the eccentric surveyor, Randolph Nutting, or "Old Randolph" as he was more familiarly called, although I had never seen him.

A winter or two after that, I was employed to survey a section in a thinly settled tract in the southeast part of the county. It was nearly all heavily timbered with beech and maple, and cut up with long stretches of black ash, willow and tamarack swamp. There was a light snow on the ground, and as we were passing through a piece of low land, I noticed a track in the snow leading up to a large, fallen, hollow sycamore tree. Thinking it some hunter's track, I followed it to the tree and looking into the hollow at the butt, I saw a rude old surveyor's compass, Jacob's staff and chain hid away in it.

"Hello," said one of the men, who was with me, "That is old Randolph's kit. He has been at work all alone over in

the big willow swamp, running out a section line. The willows are terrible thick over there, and he has been at it for more than a week, cutting lines through with his hatchet and setting stakes. He has got the brush trimmed out pretty near a rod wide for a mile, and stakes set up as high as his head every ten rods."

"Who is he at work for?"

"Oh, he is doing it on his own hook. He thinks they ought to have the line run out, and likely he is out of money, and when he gets it done he will call on them for pay."

"But will they pay him?"

"Oh, yes, the old fellow has got to be taken care of somehow, and you can't give him anything. He won't take it. He only charges ten shillings a day and we may as well give it to him that way as any other. Besides, he is terrible accurate. He won't set a corner nor tell you anything about it till he knows it is right to a sixteenth of an inch. When he measures a line everything has got to be just so. It has got to be measured straight, and the chain has to be perfectly level. He always measures a line twice over, and if it does not come out alike to a quarter of an inch he will keep measuring it over till it does."

"Where does he stay?"

"Oh, he has got a hut over in the edge of a swamp about three miles from here that he makes a home of, but he goes all around the country. Sometimes he sleeps in barns or in hollow logs in the woods. Most any of us will keep him over night, or give him a meal, if he would take it, but as I said, you can't give him anything. If he has any money he will come to the house for a meal or lodging and he always pays just ten cents for a meal, no more and no less. If he is out of money and work, he will lay out around the stacks, or in a hollow log, till he can get a job. He will go to running a man's line, where he thinks it ought to be done, whether they hire him or not. Most of us take him in and board him while he is at it, and maybe furnish him some help. He generally manages to board out his wages before he gets through with a job."

"Has not he any family or friends?"

"Only some sisters out near Vicksburg, and he won't live with them, or take anything from them without pay, anymore than from anybody else. They say he was disappointed in love when a young man, and has been cracked ever since.

"I noticed his tools were not in very good order. I should not think he could work with them."

"Oh, well, there are some of the boys that are always playing some trick on him, and they have just about spoiled his compass several times. He hardly ever uses a chain. He takes a piece of light wire four rods long, and puts handles on, and uses that to measure with. It is so light he can straighten it right out, and it is a good deal handier than a chain. It comes handy too, when he is setting his 'rock-bounds.'"

"What are they?"

"Oh that is the way he fixes the corners. When he sets a corner that he is satisfied with, he sets out four pins quite a little way from the corner, so that when the wire is drawn straight each way between the pins it will cross exactly at the center. Then he digs a big hole from four to six feet deep, and gets the biggest stone he can find and puts into it. I have got one at one of my corners that is as big as a hogs-head. It took three yoke of oxen to haul it in a stone-boat to the corner. When he gets the stone into the hole he fills in all solid around it and then drills a hole into it six inches deep and big enough to set his Jacob's staff in. That is what he calls 'rock-bounds.'"

"Has he put in many such?"

"Quite a good many. He would have put in a good many more, but he never will put in a rock-bound unless he knows the corner is exactly right, and besides a good many folks don't want to bother with him, or to haul the stones for the corner. Of course he can't haul them himself, and if he cannot get the interested parties to haul them, he generally makes some private mark so he can tell where the corner is and lets the corner go without anything."

Soon after this conversation, some one set fire to his cabin, one cold night in the winter, just for the fun of seeing what "Old Randolph" would do. The result was that the cabin with all his notes and other contents were destroyed, and "Old Randolph" narrowly escaped with his life. After that, he laid out for a time in the woods, as I was told, until his feet were so badly frozen that he could not take care of himself, and others had to care for him. He was provided for, I knew not how, until he could get around again, when the supervisor of the town where he made it his home "put up a job on him" to get him into the poor-house. I think this was in the winter of 1869 and 70. A resolution was passed by the Board of Supervisors appointing Randolph Nutting County Civil Engineer, for the purpose of planting "rock-bounds" around the county farm. He was to receive ten shillings a day for his services,

while actually at work, and was to be boarded at the county house for ten shillings a week till the work was done. He was to have whatever assistance he required from the inmates of the county house in making the surveys. I was at the time serving my second term as County Surveyor of Kalamazoo county, and had my office at Galesburg, near which village the county farm is situated. I had never met "Old Randolph," but was posted by the supervisors as to what was being done.

One cold, blustery day in January, I sat in my office writing up my records, beside a warm and crackling fire. Outside the snow was falling thick and fast, whirling around corners and piling up in great heaps across the streets. Suddenly my office door opened and a gust of flying snow-flakes burst into the room, followed by what at first sight might have been taken for Santa Claus himself. When the door was shut, and the snow-flakes melted, I saw before me a man apparently between 45 and 50 years of age, about 5 feet, 6 inches in hight, very strongly built, as if possessing great physical power. He was meanly clad in a ragged coat, pants, and shirt without a vest. Coat and pants were in tatters; the pants were without suspenders and held up by a cord around the waist. The coat was short of buttons, and was held together by a straw rope bound around him. He had no boots. His feet were wound about with rags, and over them he wore a heavy pair of woolen stockings, into which the bottoms of the trousers legs were tucked. He handed me a paper and made known the business which brought him. The paper was signed by the chairman of the Board of Supervisors and by the County Clerk, and set forth over the great seal of the county that the bearer, Randolph Nutting, had been duly appointed County Civil Engineer to place "rock-bounds" about the county farm. He came to me for field notes and information relative to corners in that vicinity. I gave him such information as I had, and allowed him free access to the field notes to copy whatever he desired. When he had got what he wanted, he drew his chair up beside the fire, enjoying the cosy warmth, and entered into conversation. I remember now but little that he said, and only carry a vivid impression that much of it showed evidence of deep thought, and careful though not extensive reading. There was much of originality and power mingled with wild wanderings, that showed an unbalanced mind. He was certainly a better land surveyor than I was, or anyone else that I knew. He was much impressed with the idea of having been appointed County

Civil Engineer, and returned to it again and again. Once, after sitting for several minutes silent and thoughtful, he broke forth, "Now then," he said, "to study. I have been thinking over our respective offices and position, and in one respect I think they are very much like those of members of Congress. A representative in Congress is elected by the votes of the people in his district. A senator is elected by the votes of the members of the State Legislature. You are the County Surveyor. You was elected by the votes of the people of the county. I am the County Civil Engineer. I was appointed by the Board of Supervisors, and have my commission as you see under the seal of the county. Now I think my office is about as much above yours as a senator is above a representative."

He went his way. The time was not propitious for setting "rock-bounds." The ground was frozen, the weather inclement, and the paupers poor help for such a surveyor as old Randolph. I think he got an inkling of the scheme that had been worked, or suspected it, for he staid at the county house but a short time and then returned to his old haunts. I saw him occasionally after that. He put up a new cabin in which he dwelt, and continued to do surveying as he had done before. His religious fervor passed away and he was inclined to be disputatious on religious matters. He attended church and would interrupt the minister in the midst of the sermon to argue a point with him, till they were obliged to "fire him out." One day some of the neighbors, not having seen him stirring about his cabin for a day or two, went to look after him, and found him tossing about in a delirium, severely bruised and hurt, and a hole through the roof of his cabin. A physician was immediately called, but he never recovered enough to tell what hurt him. He lingered in great agony for a few days and died. I tried to get copies of the field notes made by him, but there was nothing left of any value. The accumulations of years had been burned with his cabin as before mentioned. "Old Randolph" is gone, but his memory as an honest, eccentric man, and a thoroughly accurate land surveyor, is fresh and green among his old neighbors, and the "rock-bounds" he planted will perpetuate his good works when we shall all of us have been forgotten.

F. HODGMAN.

THE GRADIENTER.

WHEN we find ourselves in possession of a good machine, one capable of a great many kinds of work, it is desirable to know something of its anatomy or parts, particularly of any weak points in it.

In our *Gradienter*, which is of great and growing usefulness, is a fallacy not generally known to engineers.

The theory of this machine—or attachment to our transits—is *that the variation in the angle of elevation of the telescope, varies strictly with the number of revolutions of the tangent screw.*

So far as the *sine*, the *chord*, the *arc*, and the *tangent* of an angle may be regarded as equal, the above law may be regarded as true; but above $2\frac{1}{2}$ to 3° this assumption will lead us into error, as a few examples will illustrate.

"But," says the objector, "is not the triangle made by the 'distance,' and the 'reading' of the rod, as base and perpendicular, *similar* to that made by the length of the 'lever,' and the length of the 'screw,' as base and perpendicular?"

The reply is that these two triangles are always rigorously similar- and therefore proportional. But it does not follow that the successive increments of the angle of elevation of the telescope—and therefore that the successive increments of the reading of the rod, for each turn of the screw are equal. And here is the fallacy that I wish to point out.

These successive increments *are not equal*, as the following consideration will show.

With equal consecutive increments of the arc of an angle, the tangent is increased by an *increasing* increment. But in this case, the tangent is increased by a uniform increment; whence the arc, and consequently the reading of the rod, is increased by a *decreasing* increment.

The cause of the falling off of the rate of the increment of the angle of elevation of the telescope, is seen from another consideration. The screw, working in the direction of the tangent of the arc, which the lever actuating the telescope describes, the point of application of the screw slides over the external part of the secant of the angle of elevation, of the telescope, thereby *increasing the radius*, and as a consequence *diminishing* the increments due to the successive turns of the tangent screw, and as a consequence *diminishing* the consecutive increments of the reading of the rod,—*so that these readings do not vary in proportion to the number of turns given to the tangent screw*,—which is the popular theory of the *Gradienter*.

This erroneous principle always results in giving distances *too small*, except those determined with angles under about 3°, as before mentioned.

A few examples will illustrate. We will take an angle of elevation greater than usual, in order to show the error more conspicuously.

Suppose we give to the screw of the Gradienter scale, 30 revolutions,—two revolutions corresponding to 1 foot at the distance of 100 feet.

Then the theoretic angle due to the elevation of the telescope, would be 30 times the angle due to one revolution, or 8°, 35′, 50″. And the theoretic reading of the rod would be 15 feet.

The arc of this angle, to radius, 100 feet, would be 15,050 feet.

Regarding this amount of arc as so much tangent (as we must since it is measured in the direction of the tangent), we find the corresponding angle of the elevation of the telescope to be 8°, 32′,—thus showing a falling off of 3′, 50″ from the estimated elevation of the telescope,—and a consequent falling off of .115 feet in the reading of the rod,—and as a further consequence, a falling off of 11.5 feet per 100,—or 115 feet falling off per 1000, in the distance.

In the same manner, 22 revolutions of the screw would show a falling off of 1′, 35″ in the theoretic angle of elevation of the telescope, and a corresponding shortage of 4.6 feet per 100, or 46 feet per 1000, in the distance.

And 15 revolutions would show a shortage of 30″ in the angle of elevation, and 14 feet per 1000, in the distance —the theoretic angle of elevation being 4°, 17′ 55″.

In the same manner, 10 revolutions would have a falling off of but 10″ from a theoretic angle of 2°, 52′, with a corresponding shortage in the distance of but 5 feet per 1000.

Again if we give the Gradienter screw the number of revolutions corresponding to 90°, the telescope should be elevated to a perpendicular position, and the reading of the rod should be *infinite*, to correspond with the popular theory of the instrument.

But, on 100 feet radius, the arc described is 78.54 feet. But as this arc has been projected in the direction of the tangent, the elevation of the telescope is only that due to so much tangent, or 38°, 9′,—so wide is fact from the popular theory,—and the reading of the rod is 78.54 feet, instead of infinity.

If we should require to work up an incline of more than about 3°, we should first slack the clamp, and turn the telescope up to the given elevation, before clamping the Gradienter to the telescope. By this means we preserve the available part of the Gradienter for the reading of the rod.

It will be remembered that two years ago I presented a paper on this same topic. But after a time some further explanation was asked for, but before I could make it, our report went to the printer,—thus the article was not published.

In this treatment I have endeavored to be so full and elementary that further explanation will not be wanted.

I gave, too, a method of making corrections for angles greater than 3°, by means of a table of errors.

A better means of avoiding error is to be found in modifying our telescope. *Use the inverting eye-piece.* By this means, with a given length of tube, we may have a *greater focal length*, and as a consequence a *greater power.*

We will have, too, *more light*, because of less loss by absorption. And, with the greater focal length of object glass, we will have better *definition*, because of less spherical aberration.

With the above advantages we may *shorten* the unit of measure on the rod,—say make it .4 instead of .5 of a foot at 100 feet, for one revolution of the screw. This will help to keep the angle of elevation of the telescope within the limits desired.

H. C. PEARSONS.

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ILLUSTRATED MANUAL AND CATALOGUE SENT ON APPLICATION.

INITIAL WORK ON THE MEXICAN BOUNDARY LINE SURVEY, IN THE YEAR A. D. 1849.

ENGINEERING, civil and mechanical, has made great progress within the last half of the century. The achievements of the modern engineer, bold, practical, many-sided and far-reaching, excite astonishment. In the mediæval ages such marvelous exploits would have won for him the name of wizard, and his reward most likely would have been a fiery trial at the stake.

From the advanced position attained, in the face of accomplished facts, members of this honorable Society will pardon me for asking them to go back with me to a period indeed full of interest and enterprise, but not illuminated by the brilliant light of modern science and art.

Forty years in this "rapid transit" age, when steam and electricity are prime factors, is a long step backward. The distance is immense when measured by the world's progress during that time.

In 1849 the Mexican War had closed. The newly acquired territory of California was a remote region to be reached only by sailing around Cape Horn or perilous overland journey over high mountains and across inhospitable deserts controlled by savage foes. Farther India and China were better known to the civilized world than fabulous California.

In 1848-49 the people of the Atlantic States were startled by whisperings of gold discoveries at Sutter's saw-mill, on the headwaters of the American River.

These whisperings, faint at first, and hardly credited, soon became so loud-voiced, that their echoes went resounding through the world. Then began a rush and scurry of people to the new El Dorado as had never been seen. The Crusades, precipitated by the preaching of Peter the Hermit, were nothing in comparison, as to numbers and results.

The lust of gold proved more absorbing than religious zeal. The whole world was aroused. Hosts from all lands, by devious and difficult ways, rushed for the foot-hills of the majestic Sierra Nevadas, confidently hoping to find in the golden sands, fortunes unlimited.

Meantime, portions of our army, fresh from the victorious battle-fields of Mexico, in order to take possession of this newly acquired land, in the name of the government of the United States, were slowly fighting their way across the continent or being tossed by ocean waves, in sail vessels, on the long voyage around South America. Simultaneously, or in the

winter of 1848–49, the Government organized and sent out a commission to survey and mark a boundary line, under the treaty with Mexico.

The commission consisted of Col. and ex-Governor Weller, of Ohio, Col. A. B. Gray, of Texas, the first named, Commissioner, and the second, Surveyor, under the treaty. Attached were about fifty gentlemen, surveyors, engineers, secretaries, a surgeon, and quartermaster, all civilians, drawn from many States.

Major Emery (afterward General), was chief astronomer and commandant of escort. On his staff were several young U. S. engineers and a corps of computers. The military escort was to join the commission at San Diego. San Diego, on the Pacific, was the designated point at which the survey was to begin and where the commission was to rendezvous. The route by the isthmus was the one selected to move on. At that time it was difficult to reach California by any route.

The headquarters of the commission were at New Orleans. It was no easy matter to reach even that point in those primitive days in winter. There were no railroads from Detroit to Buffalo; none from Albany to New York, direct, and very few south of Washington.

After some delay at New Orleans, the commission, with instruments, provisions and stores, finally embarked on a government steamer in January, and sailed for the port of Chagres, on the isthmus. Canoe transportation was used on the Chagres River as far as Gorgona, and mule trains thence over the mountains to the City of Panama, on the Pacific side. At that time surveys for a railroad were being made.

The commission was detained three months on the isthmus for lack of transports.

As yet, there was but one steamer on the water between Panama and San Francisco. She had sailed north not to return very soon. Her crew deserted her as soon as she reached California and hastened to the mines.

After a while the second steamer arrived from around the Horn, and took on board a detachment of the commission. The third steamer which sailed from New York after the commission had left New Orleans, under command of Captain Porter (later an admiral), put in an appearance in May. By strong pressure on the part of the government, the remainder of the anxious commission was received on board that ship.

Panama was crowded with adventurers. They were in great stress. To the unacclimated, the dirty, close-built, walled city was a hot-bed of fever. The imprudent, ill-fed,

anxious northmen sickened and died rapidly; cholera followed in their wake. This was a new disease to the nation and filled them with terror and consternation. They died by hundreds. Wailings were heard in almost every house, as when the first-born were smitten in the land of Egypt. Priests with bell, candle and incense paraded the streets; trains of powder were lighted and cannon fired to drive away this mysterious plague.

The desperate California adventurers were mad to escape from this wretched city. They seized upon every available mode of egress. Whalers, merchant ships, schooners, sloops, yawl boats and even the native dug-out canoes were pressed into ocean service as transports. It was a dire time. Strange to say some of those small boats and canoes, after months of peril and hardships, reached Lower California. The strong northwest winds prevented further progress.

The steamer which carried the writer, though crowded to suffocation almost, in due time arrived at San Diego. The voyage near the coast line of Central America and Mexico was very pleasant. The Pacific Ocean did not belie its name.

The writer's first experience of California, was a hard night spent at Point Loma, in one of those hide-houses so graphically described by Dana, in his work entitled "Two and a Half Years Before the Mast." Twenty-two thousand hides were stored therein. Though dried like horn, these cast-off wrappers of California's ancient wealth—the cattle on a thousand hills—were malodorous and the trysting place of innumerable fleas. A couch on these bullock hides was anything but a bed of roses.

The Pueblo of San Diego, at which the commission took post, lay several miles inland but still near the bay, on a small stream, dry most of the year. A little adobe-built town of low, red-tiled houses, built around the plaza. A few outside buildings completed this isolated Spanish town. The fine bay of San Diego, roomy enough for a large ocean fleet, lay in front, and beyond, the Pacific Ocean in its vast expanse. In the rear, bare, rounded hills were succeeded by distant azure mountains. These, and a salubrious climate, were the chief attractions.

The stars and stripes were floating gracefully from a tall flag staff in the plaza, and we Americans saluted the flag with joyous shouts, with some tears welling from our eyes.

The natives of the country, their habits and costumes, have been so often described, I will not dwell upon them.

There were plenty of horses and cattle feeding on the hills —the only wealth of this section.

The roll call, made about the first of June, found all the members of the American Commission present in San Diego. Several companies of U. S. troops were posted there. Many of the officers with the command, afterward in the war on the Union, became distinguished generals and freely shed their blood for their country, Emery, Heitzleman, Lyon, Whipple and others. The Mexican Commission had not arrived, but came in on the last of June. The Commissioners, a distinguished Mexican general, Garcia Conde, and Senor Salazar, surveyor under the treaty, with a large corps of surveyors and engineers and staff officials, were many of them accomplished men, speaking besides Spanish, French and English. The interpreter (each commission had one), Senor Iturbide was the son of the ex-Emperor of that name, and had been educated in Philadelphia.

The Mexican army escort was a disreputable band, without uniform, and taken from the prisons of Mexico mostly. I speak of the common soldier. Subsequently we Americans found them to be an element not of defense but offense,—more to be feared than the Indians. Many women were with them as camp followers.

On the 4th of July, the American Commission gave the Mexicans a dinner and ball. It would be hard to tell which side was most gloriously drunk—with patriotism.

At length, after long waiting, a program was formulated, and actual work on the boundary line survey begun.

According to treaty stipulations the boundary line, in general terms, was to be run as follows:—

Beginning on the shore of the Pacific Ocean, one marine league south of the southernmost point of the Bay of San Diego, thence easterly to the junction of the Gila with the Colorado River, thence up the Gila to its source, thence across to the headwaters of the Rio Grande, thence following down the middle of that stream to the Gulf of Mexico.

In passing, I beg to state that THAT is not the present boundary line between the two republics. By the Gadsen purchase, in 1853, the line was carried further south so as to include a portion of Sonora, now known on the maps as Arizona.

The camp of the chief astronomer was moved to the head of the bay, some 15 miles south of the Pueblo. The surveyor's camp was pitched near it.

The initial point of the line was to be fixed astronomically. Also the point at the mouth of the Gila.

A party of astronomers were at the same time sent to the Gila under Lieut. Whipple, U. S. Engineer, afterward General Whipple, killed at Chancellorville, Va.

A line drawn on the map from the astronomical point on the Pacific coast to the astronomical point at the mouth of the Gila, would give the course to follow and mark on the earth's surface as the true boundary line.

The surveyor, Col. A. B. Gray (later on the Confederate engineer who fortified Island No. 10 in the Mississippi River, and was accidentaly shot to death on board a transport), organized his forces for field work. His assistants were a motley group—mostly political appointees, and as innocent of surveying as sucking doves. A few were trained engineers, surveyors and draughtsmen of experience.

Mr. Gray's first duty was to measure the marine league before spoken of. A survey of the bay of San Diego had to be made in connection.

The measurement of the marine league was assigned to the writer; the survey of the bay to Charlie Whiting, a West Point graduate (later on a colonel of cavalry in the Union army).

But, before proceeding to work, Col. Gray ordered the writer to make a topographical survey of a small valley leading to the old mission of San Diego, six or seven miles from the Pueblo.

The writer chose his party from the young gentlemen who, on the voyage out, had constantly boasted of their engineering skill and experience. The instruments to be used were a common chain, compass and a level.

We started at the flag staff, the writer kindly managing the instruments until beyond the reach of critical observers in the Pueblo. Then he told his assistants to take the instruments and go ahead, nicely sketching in the topography in their field books. But no progress was made, Mr. H. at the compass being in doubt as to which was the north end of the needle. Mr. E. declared there was nothing to sketch but a straight line from one station to another, and so on. The survey was not completed, but an inglorious retreat was made to headquarters, where a game of poker restored the good nature of our skilled engineers. Comment is unnecessary.

The writer then made up another party from young men who had all along admitted that they were entirely ignorant of practical surveying. They were well educated law students

from the northern States. By a little drilling they soon became efficient workers, and in the course of time formed an admirable party. Many of our political appointees never did a stroke of work on the survey.

Perhaps you may have observed that no mention of common men has been made, and it would seem that the Commission was made up entirely of officers. This is true. There were really no "high privates." Some destitute emigrants from Texas, stranded on this shore without a penny, consented to work awhile to recuperate their finances, before going to the gold mines. The cook in our camp, who had acquired some skill in turning flap-jacks, while coming across the plains, was paid $500 per month, while the writer received $800 per year and rations, and the first assistant $1000 with a liberal supply of hard tack and *carna*. These terms were made on the Atlantic side, before the discovery of gold, and was considered good pay *there*.

During our first summer in San Diego, in Uncle Sam's employ, the embryo cities of San Francisco, Sacramento, Stockton, and others, were springing up and expanding. We were offered $1000 per month, with city lots thrown in, to go there and lay out the towns. But under these great temptations we remained true to our colors, every man. How this fidelity was rewarded by a generous, paternal government will be seen further on.

There was nothing difficult in the survey of the marine league. The country crossed by it was low, level, pasture land, dotted with clumps of sage brush. The land was cleared and leveled. A French metre chain was used in the measurements. It was carefully stretched by a spring balance. It was aligned by a theodolite, and was transferred by careful offsets. The work was done accurately but rapidly. No such precision, however, was required as in the measurement of a base line for triangulation. The initial point was soon fixed on a commanding bluff, and a stone monument set up there. Later the joint commission assembled at the place, and with some speech-making, and breaking of champagne bottles, dedicated the monument.

The Mexican surveyors were supposed to be assisting in the work on the marine league all the time. But they never took a hand in. Occasionally a few gaily dressed fellows, with jingling spurs, would ride down upon us and criticise the plebeian Americans, who would stoop to work, in pure Castilian.

From first to last, while we were there, the Mexican

surveyors did no work unless in the night time. How they amused themselves we were too busy to ascertain. But it was decidedly a one-sided survey, the whole of it. Yet we Yankees were content to have it so.

The chief astronomer, after months of "star-gazing" and reams of computations, finally *fixed* the initial point on the face of the earth to the satisfaction of all concerned. In order to do so, some nice triangulation was necessary.

His special work done, the writer spent a pleasant month or two with engineer Whiting on the survey of the bay. In that glorious climate, with cloudless skies, our duties were delightful, and camp fare good. Game was abundant,—deer, jack-rabbits, quail, and curlew could be had at all times. The waters teemed with fish, notably herring, mackerel, and rock cod. The only drawback in surveying and hunting was the fear of rattle-snakes. They abounded in great numbers in the tall grass and cactus and sage brush. We had many narrow escapes. The Mexican soldiers killed them for food.

While this work on the coast was progressing favorably, the astronomical party at the mouth of the Gila was busy star-gazing, much to the astonishment of the wild Indians.

A semi-military expedition was sent out from the coast across the Cordillera range of mountains, to explore the country and to establish a signal station, on the east side of the range, where the towering escarpments offered a wide view of the great desert and of mountain peaks on the far-away Colorado.

By preconcerted action, on certain nights, rockets were sent up from this station and at the one near the mouth of the Gila on Pilot Knob. The object was to thus determine the difference in time—longitude—between the two places. But the rockets were not seen, from some cause not explained. The distance between the two points, on the air line, was about 100 miles. So this party returned to camp, *not* covered with glory, but with fabulous stories as to hardships and hostility of the Indians.

In October, 1849, a grand effort was to be made. It was determined to send a party to the Gila, 200 miles away, across the unexplored mountains and desert, following as near as possible the assumed boundary line. Col. Gray, surveyor, was in command. The writer acted as his assistant. We were well fitted with a train of pack mules, carrying surveying instruments, blankets, and rations. The officers, cook, muleteers, guide, and four men constituted the party, escorted by a corporal's guard of infantry *on foot*. Cavalry would have been more

efficient. Our rate of progress was at all times fixed by these *foot-men*,—an absurd arrangement!

The speed of progress was timed, and it was found after several tests to be about three miles per hour. Thus was the distance from camp to camp roughly obtained. Topographical sketches were made by the writer on mule back. Sextant observations were taken at night. The invariably clear skies favored such work. Detestable work it was after a long day's march across those rugged mountains! Four or five hours sleep was all; too little to recuperate our worn-out bodies.

But the journey across the mountains was full of interest, and the air as exhilarating as wine. Grand peaks and deep gorges everywhere; some tall climbing was done and much rapid sliding. Desolation seemed to reign; the eyes tired of gazing upon the bare, broken, glaring, yellow rocks and jagged peaks. But as we struggled forward, hot and jaded, our trail would descend a narrow winding gorge and finally lead us out into a beautiful grassy valley, with a murmuring stream of sparkling water winding through it and lined on either hand by far-spreading, live oaks, whose shining, deep green foliage was very refreshing. There were many such valleys *en route*, and they afforded us delightful camping places, where we fain would have lingered many days.

As we marched, day after day, not a living thing was seen outside of our own party. There was some little shrubbery noticed outside the valleys. An occasional oak tree or rather shrub, loaded with clusters of sweet acorns, and some scrubby plum trees, were all that we noted. Once in a while a stark, leafless cactus plant obtruded upon the vision, adding to the desolation of the scenery. We found numerous *caches* filled with acorns, evidently the Indians' stores for winter. But where were the dreaded Indians we had heard so much about? Lurking somewhere no doubt. The solitudes were so profound that the sound of our own voices would often startle us. As we penetrated deeper into the recesses of the silent mountains we began to notice on commanding peaks in advance, tall, thin columns of smoke shooting up. These were the alarm fires, or signals of the Indians. They were evidently tracking and watching us. At length a bevy of these naked savages dropped into our camp. They were armed with bows and arrows, and were by no means hostile. A gift of hard-bread and tobacco increased their good nature.

They squatted around our bright camp-fires ready to snatch at any food thrown to them. When bed-time came, they were driven outside the line of sentinels. Instead of

building a fire for themselves, they would dig a hole in the sand with their claw-like hands, like a hog wallow, and crowd themselves into it for warmth. They were miserable "diggers." They disappeared in the morning, like dew, and were no more seen until the following evening.

During the night we found the air so chilly that we kept our camp-fires blazing and a pair of heavy blankets in addition to our clothing—none too much for comfort. We had no tents, but threw ourselves on the ground with feet to the fire, and a saddle for a pillow, and slept like very tired men.

Often baffled and turned from its course, the party nevertheless made steady progress eastward, coming out finally on the eastern escarpment of the mountain range. Before us lay spread out the great desert, looking through the shimmering heat waves, like a great yellow sea, stagnant and sullen. Where we stood, nothing but huge boulders and jagged peaks, crumbling and falling, met the eye. No water, no vegetation, only glaring rocks which struck terror into the stoutest heart. The air was so light that a shout, a musket shot, could be heard only a few feet. There appeared to be no break in this solid battlement through which we could escape to the desert. The situation was full of gloom and doubt. We *must* get out of this! And, after toilsome searching, a detached party found a slight break which would just let the mules crowd through. Down we plunged, the mules often sliding hundreds of feet on their haunches. As we advanced, the gorge widened, and before we had reached the plain, became a narrow valley, with signs of water. Six hours were consumed in the descent. The cool, pure air of the mountains we left behind only to plunge into tropical climate. As we defiled out of the gorge, hot, tired, ragged and parched with thirst, we suddenly struck a stream of running water—Carrizo creek. To plunge noses into it, both man and beast, was the work of a moment.

Carrizo creek is shallow; the waters well up suddenly, run a few hundred yards, over a sandy bed and then disappear,—a peculiarity of many western streams.

Resuming our march, we soon struck the emigrant trail in the desert. This Colorado desert is about ninety miles wide east and west, and was doubtless once the bed of the ocean—an extension of the Gulf of California. It is a level expanse with little vegetation. The road now passed over long stretches of clay and gravel, alternating with loose sand. Numerous dry arroyos were crossed, some of them many yards wide, with steep, clearly outlined banks—in fact, rivers without water. No water could be found. Heat and thirst became trying.

We camped the first night on the desert, without forage or water. The distress of the poor mules was pitiable. We passed numerous emigrant trains toiling toward the land of gold. They had spent six months in the wilderness; they were worn out, ragged, half starved, impoverished, almost hopeless. The splendid trains with which they started in the spring were reduced to a sorry condition. Horses, cows and mules, singly, or two of different kinds, were hitched to dilapidated wagons, or carts, extemporized from broken wagons. Some families were reduced to an ox or cow upon which their baggage was packed, while the men and women trudged slowly along through the deep, burning sands. They were objects of pity.

On the second day of the desert march we reached Salvation Camp. At this point blessed water was found; oh, how it was enjoyed. We were told that only a short time before, these springs burst out of the arid plain, as if by a miracle, to the salvation of hundreds of perishing emigrants.

The next year, hot mud springs were found there. All these phenomena were doubtless the effect of earthquakes. On our march we felt several shocks, and were almost overcome by the heat that accompanied them. The sky was like brass, the air still and hot as a furnace.

We found many hundred people resting at Salvation Camp. In the rich soil, grass had already sprung up, proving that the desert only needed water to show its fertility.

Among the emigrants we found a large corps of U. S. officials sent out to take possession of the custom houses in California. Mr. Collier was collector. A squadron of dragoons guarded the train. The whole body was in a starving condition, living on one-fourth rations. They were clamorous to be led by our new, short route to the coast. Col. Gray consented to act as the Moses to lead them out of the wilderness into the land of promise. He ought not to have assented; his duty was to lead to the Gila in the opposite direction. But the pleas of starving men were powerful. He ordered the writer to continue on to the Gila, and make the necessary surveys. The writer remonstrated, hinted that the supervision of that work, on the part of the surveyor, the only person known under the treaty, was imperative; that he would conduct the Collier expedition into California. "Oh," replied the Colonel, "YOU cannot find the way with them." The logical question followed this reply. "If I am incompetent to conduct this expedition over a fresh trail, how in the name of Sinbad, am I to get back with my own party, a

month hence?" The answer was, an order in writing, to "pull out" at 7 P. M. Sunday evening.

Obeying gracefully (*because he had to*) the writer only stipulated that he should not be bothered with the corporal's guard, which was accordingly left at Salvation Camp. Four men were selected to go with him, including a soldier, without his musket. Each person had a mule to ride, and there were several pack mules in the train to carry instruments, provisions and baggage. A rapid march was what was aimed at, hostile Indians were a secondary consideration.

Promptly at 7 P. M. the little party bade adieu to anxious comrades and departed. It was a clear, starlit night, and the commanding officer took his course by the stars—an effort to follow the emigrant trail soon proved futile. The shifting sands speedily obliterated all footprints, leaving us adrift on the desert. The march was slow, not faster than a walk. The commander had to be constantly on the alert in order to keep on his course, and prevent his sleepy, tired men from straying. Often they left the line, and often they tumbled headlong from their mules, having fallen asleep in their saddles. When it was necessary to stop the train to adjust the baggage, the idle ones would immediately fall asleep on the soft sands.

In the morning, Cook's well was reached. By digging, we obtained some brackish water with which to boil our coffee. After an hour's stop we resumed our march; we toiled and waded through the loose sand sullenly, almost hopelessly. The sun was intensely hot, and the fine, impalpable dust powder of the desert, hung to us, like a mist, filling eyes, nose, mouth and ears with dust. Even our clothing was saturated, and our sweating faces were plastered with it, so that the Indian was fair in comparison. Thirst, the greatest of all the traveler's afflictions, tormented us. The brackish water in our canteens, from Cook's well, became so tepid and slimy that we threw it away. Our lips became swollen, cracked open and let the blood run out. Our tongues became so swollen that articulation was difficult. Faces became haggard and eyes staring, through their grimy masks. Our pack animals shared in the common distress. Riding became so fatiguing that a change to foot was often resorted to, but was speedily abandoned. In the loose, deep sands a walk of a few hundred yards would exhaust one.

This dreary march was enlivened, if such misery could enliven, by numerous passing trains of weary, way-worn, starving, almost hopeless, emigrants. The route was marked by broken wagons, the irons of wagons, which had been burnt

for fuel, by trunks, boxes and furniture, by dead mules, oxen, cows and horses. Not infrequently we saw little mounds of sand with stakes at head and foot, whose purpose was unmistakable. With grim humor some American had placed a dried skeleton of a horse or ox on its feet, with head and tail erect, with a legend, "This is the way to the gold mines." Carcasses in this dry atmosphere never became putrid, but in this case in the starved animals, there was nothing to putrefy but hide and bones.

At 4 P. M., after leaving Cook's well, we struck an Indian village on the banks of the Colorado. Thrice welcome river, never was anything sweeter than this yellow flood! We were now fourteen miles from the astronomical camp at the mouth of the Gila.

But we came near not reaching that haven. The men tired and worn out, and attracted by the pleasant Pimo village, with its green pastures and cornfields, and, perhaps, by the half nude young squaws which met their gaze, were determined to stop for the night. To have done so, would probably have been death to all. There were mutinous displays, but the commander, placing his troop in front, drew his revolver and ordered it to trot for life. None too soon did we escape from the village; a buck, with hostile intent, intercepted us, and the commander had to knock him down with his horse pistol, because of presumption in seizing his bridle. We hurried up the river, in hot haste, the Indians following. But fortunately they had no horses, and were armed only with clubs.

These Indians were at heart hostile, and were only kept in check by the camp of U. S. dragoons stationed at the Gila. After this force was withdrawn, they attacked and killed a party of emigrants. Two companies of militia were sent out to chastise them, and did it so effectually as to annihilate the village.

At 10 P. M. we rode into camp at the Gila, after twenty-seven hours of continuous riding. We were heartily welcomed. Lieut. Whipple, of the engineers (in after years he laid down his dear life on the fatal field of Chancellorville), took me to his tent and fed me.

Our commander, after a hearty supper, unwashed and full dressed in his dirty suit, threw himself on the ground and slept twelve hours solid without stirring. One day was required for rest. On the second day of our arrival, a survey of the junction of the Gila and Colorado was made by triangulation. Our transit instrument was so badly jammed as to be

useless. Lieut. Whipple kindly lent his theodolite. There were no boats to be had, so Dr. Parry swam the swift stream (Colorado) and set up stakes for me at the mouth of the Gila.

Time and space will not permit of a description of this place. Suffice it to say, if there is a hotter place on the continent, in October, than at the mouth of the Gila, the writer has not found it; and if there is a land more sandy, more rocky, more sterile, more terrifically desolate, than this washed by the Colorado and Gila, geographers would have difficulty in pointing it out. Some profane person has aptly described the region as a "hell on earth." There is but one redeeming feature in the landscape, namely: the grand, jagged, many-colored, heaven-aspiring mountains, crossing the eastern horizon. These are best appreciated in the distance.

The return march to San Diego was full of toil, danger and suffering, for starvation was added to the list of hardships. We reached Salvation Camp more dead than alive. Our corporal's guard was well, but had about given us up. Col. Gray had fed the Collier party so well that no provisions were left for the surveying party. The writer subsisted for several days upon a handful of broken crackers each day, which the corporal kindly gave him from army rations. No time was lost. We pushed forward toward the sea with what energy was left.

Twenty-five miles from San Diego we reached a Spanish rancho. Here we encamped. A sheep was purchased, butchered and boiled in a camp kettle, and, as soon as cooked, was devoured at one short sitting; the whole command participating. Famished wolves could not have shown less ceremony.

At length the writer, with his little command, reached headquarters without loss of a man, beast or baggage.

On reporting to the commissioner, we found that august official lying on a cot, ill from a pistol shot. Displeasure at the untimely return of Col. Gray, with the Collier party, roughly expressed, had caused a row, in which the commissioner was shot by a revolver in the hands of Col. Gray. Pistol practice and the duello were quite fashionable in those days.

The commissioner was pleased to say to the writer that he would commend him highly in his next dispatches to Washington.

Those dispatches need not have been sent for all the good they did. Note results further on.

Thus ended the work on the Mexican boundary line survey for the year 1849. The approaching rainy season, it

was assumed, would stop the work, if there were no other reasons for suspension.

An election of two United States senators was to occur at Monterey in the winter. Col. Weller was an aspirant for one of these positions, for the new State of California. But before he left us he had been removed, or expected to be, by the new administration under General Taylor.

Col. Fremont was nominated as his successor as Commissioner, but we never had a glimpse of his distinguished person. He too had a senatorial bee in his bonnet. He cruelly left us to our fate. The grand Commission, in the absence of the high officials, was reduced to a pitiful lot of young men, quartered during the long rainy winter, in the mud hovels of San Diego, or in tents, without one cent of pay, subsisting upon hard bread and tough beef. There were no books and no amusements except gambling. Finally an agent was sent down to settle with us, giving unnegotiable *due bills* on the government at Washington. We were not dismissed, nor disbanded, nor mustered out, simply let alone. Our contract with the government required that we should have transportation home. At that time a steamer ticket to New York cost $500. No promises for the future were made. The resumption of work on the line depended on future appropriations by Congress,—so did the cashing of our due bills.

Thus incontinently "left" in a foreign land, as we looked at it, with no hard bread and beef guaranteed, there was nothing left for us to do but "move on," like poor Joe. The writer, by hoarding, after 14 months' faithful service, had money enough to buy a steerage passage on the steamer Oregon for San Francisco. He wrote to his father for redress. A member of Congress from his district was appealed to. An answer was received to this effect:—

"Whereas, your son deserted from the Commission and ran off to the gold mines, therefore, resolved, that he is not entitled to favorable consideration, but, on the contrary, should be punished."

As before stated, this base son of a worthy sire, was tempted soon after he landed in California, to desert his post, in consideration of pay at the rate of one thousand dollars per month and city lots thrown in. But he and his comrades stood by the colors until there were no colors to stand by.

Some of the methods of our Uncle Samuel are very queer indeed. No honest man will ever fall in love with those methods, or submit to them longer than possible. If Indian agents and others do, in self-defense, cheat our venerable

relative, the writer will not be the first man to vote to send them to purgatory. The gratitude of republics is inspiring.

JOHN H. FORSTER.

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A. C. BOTH,

Civil Engineer, PORTLAND, ME.

PROGRESS OF DRAINAGE IN THE HURON PENINSULA.

A GLANCE at any map of the Huron Peninsula will show that in its central portion is the source of the following rivers, viz.: Cass River with its several branches, whose waters find an outlet in Saginaw River; Black River, with its main branch, Elk Creek, finding an outlet in St. Clair River, also the Pigeon, Barques and Willow Rivers, with outlets in Saginaw Bay and Lake Huron. Closer examination will show that this district comprises almost the whole of Sanilac County, a few of the southern townships of Huron County, bordering on Sanilac, and a few of the eastern townships of Tuscola County. At the headwaters of these several streams are uniformly found marshes or swamps, varying from a few hundreds of acres to several thousands of acres in area, and it is the reclaiming of these marshes and converting them into tillable and valuable farming lands that constitute the drainage operations of the "thumb" of Michigan. Each of these marshes is, for the most part, nearly level, but all occupy elevated plains not less than from 200 to 300 feet above the mouths of the various rivers which form their final outlets. The largest and most important undertakings, and the ones that, if any system could be followed, should properly be done first, are not yet commenced; that is, the opening of large channels at the head waters of these different streams to make the main outlets for a more thorough system of drainage. On the contrary, owing to unavoidable circumstances, the drainage goes on piecemeal, by making one small drain here and another there, as improvement and settlement of the land demands. These, for the most part, seek outlets in the sluggish head waters of the streams already mentioned.

Notwithstanding this want of system and inverted order of proceeding, the work already accomplished is very valuable, and is, perhaps, the best that could be done with our present drain law, and the partially developed condition of our country.

To make this more plain, allow me to introduce a few words regarding the agricultural history of the Huron Peninsula, for drainage and successful agriculture go hand in hand, though remember, it is only surface drainage to which I shall refer. We are not far enough developed to do much in the way of tiling.

Every one knows that, originally, this peninsula was covered with some of the most valuable pine Michigan ever pro-

duced, but unlike the light and almost worthless sands of the central and northern portions of Michigan, it has a loamy soil, inclining to clay, rather than sand, yet not unduly hard. Again, this land is interspersed with the marshes already referred to. These marshes have a mucky surface with clay subsoil, the muck varying from a few inches to several feet in depth, usually, however, not deeper than two or three feet.

It was not until two or three years after the fire of 1871 swept over the country, that lumbering ceased and agriculture really began. For several years it progressed slowly, for the inhabitants of a lumbering country are loth to give up the old pursuit and settle down to agriculture as a business, and not till several years had elapsed, and many of the woodsmen had moved out and given place to settlers who are really farmers, did the business actually change, and the peninsula forsake the aspect of a lumbering country and appear like one given to agriculture. The fire of 1881 followed, and immense tracts of windfall and dead timber were cleared as if by magic, thus offering opportunities to the poor man in search of cheap homes, and good lands, unrivaled only by our western prairies. Immigration rapidly followed, and soon the entire peninsula was settled with sturdy farmers living on small tracts of land of which they were the real owners.

About this time the drain law of 1881 appeared, which, though imperfect, took long strides in advance of the old law which had produced little but litigation and disgust. An impetus was thus added to drainage, for the people were ready to demand it, and many miles of drain were successfully constructed. Other amendments have been made in 1885 and 1889, but all are in the old groove, no practical changes having been made.

This now brings us face to face, ready to talk intelligently about our subject, as we find it today.

As already seen, Sanilac County includes the largest part of the drainage area in question, and I find that the work is nearly all being done in Sanilac County. The Huron County drain commissioner reports on hand 17½ miles of drain, which he hopes to complete this year. The Tuscola County commissioner reports but 8 miles, while the Sanilac County drain commissioner will complete upwards of 50 miles and has 100 miles in process of construction. Huron and Tuscola Counties have each less than 10 miles of drains in the hands of township drain commissioners, while Sanilac County could show more than both, being constructed by township drain commissioners.

One township, Koylton, in Tuscola County, deserves especial mention for the systematic way in which it has taken up its drainage, under its own commissioner. It has constructed, in the last two years, in a first-class manner, about 7½ miles of drain, at the head waters of White Creek, making a ditch 8 feet wide on the bottom near the outlet and 3 feet at the upper end, and averaging about 4 feet in depth, with slope of banks 1.1. Also 6 miles of laterals tributary to this main outlet. These have been done at moderate cost. Sanilac County has completed many as successfully, some being longer, but in no other case has a district been taken up and as thorough work made as in the township mentioned.

The excavating is mostly done with teams and scrapers, or with shovels, the work costing from 8 to 12½ cents per yard. The contracts are all let at public lettings to the lowest bidders at prices given per rod.

We offer a fine field for dredges to operate in, but under our present law the pay is too insecure to induce contractors to bid. In the near future, we hope to take up the head waters of Cass River, and make a good channel for a distance of about 14 miles, and to do the same with Black River and Elk Creek for somewhat shorter distances.

Our actual progress, though considerable, is not what I hoped to be able to report when I promised to write this paper, and really I am not proud of it, when I read of what is being done in some of the drainage districts of Illinois. Even as it is, the work accomplished is valuable, and it would not be exaggerating to say, that the drains are adding value to Sanilac County of not less than $75,000 per year.

METHOD OF STAKING OUT.

The manner of staking out used by most engineers in the peninsula, as well as myself, is essentially the same as described by Prof. Carpenter in his paper on drainage, and already published in our proceedings. But, knowing how eager young men are for details, I will give a few, at the risk of repeating, hoping that in so doing I may help some beginner, and thus partially pay the debt I owe the older members of this Society for similar articles. We stake the center line marking the stakes from the outlet, as the law requires, and set stakes at 2 chains, or 8 rods apart (I would prefer using the 100 foot tape, and staking every 100 feet, but have not yet tried to break over the custom). If the drain commissioner is with me, I appoint him flagman, and direct him to go ahead to a point where it is necessary to change the course, or, if

that is too far, to some point on the already determined line. Then the chainmen are started in, the rear chainman swinging the other into line between himself and the flag. They use three marking pins, two being carried ahead each time, thus leaving one in the ground at the stakes, from which to measure. When the two pins taken ahead are set, the head chainman calls "*stake*," and a man with stake and ax steps into line at the pin, facing the transit man, who gives exact line, and sees that the stake is kept in line till driven. The stake man then proceeds to the next stake point, having procured a stake from another asssistant. In the meantime the rear chainman has dropped his end of the chain, walked ahead to the stake, and handed his two pins to the head chainman, and the work proceeds as before. When an angle point is reached, the head chainman stops, holding the end of the chain at that point, the rear chainman steps forward to the last stake or pin and reads the chain, calling it out to the transit man, who makes the proper record. The transit man also records the magnetic bearing of all courses.

For leveling, stakes are set opposite each center stake, far enough one side to be on the berm of the ditch, between the excavated earth and bank of the ditch. At each of these stakes hubs are driven level with the surface of the ground. The levels are taken on these hubs, and the hubs remain there for the use of the contractor in digging and the commissioner in accepting jobs. This system of staking out, where good work is done, good stakes and good hubs driven, gives the best of satisfaction. The surveyor should not do slouchy work, nor allow any of his men to do it for him. He alone bears the praise or blame, according to the success or failure of his work.

I keep alignment notes in a tabular form much as shown by Beden in his valuable paper on Drainage, already published in our proceedings. The table shows method:—

Angles.	Bearing.	Station.	Chains.	Course.	Remarks.
0	N. 25° W.	0.000	0.000	20.25	"0"=4 chains east, and 15 chains south of n.e. cor. sec. 10, t. 10 n., r. 12 e. Terminus=Etc.
1	N. 40° W.	10 + 0.25	20.25	21.05	
2	N. 30° W.	20 + 1.30	41.30	38.70	
Terminus		40 + 0.00	80.00		
			Proved, 80.00		

I keep topography notes on the right hand page of level book, using for right, the part of the page on the right hand

when standing with face down stream. I keep general width of swamp, as estimated by the eye, or other knowledge, by drawing in an approximate contour of the swamp on each side of a center line and marking estimated widths at abrupt turns and other important points. It is important to show all streams entering the same, their approximate size, and some notes as to character of contiguous high land, character of soil in swamp, and such other facts as naturally suggest themselves. These can form your basis, together with levels, for determining the size of drains. These, too, are copied on the map, not as an infallible guide to the commissioner in assessing, but to aid him in his work.

A profile is carefully made from the level notes to a scale of four chains to an inch, horizontal, and six feet to an inch, vertical. This should show all the facts that can be of use in the construction of the ditch, and give all the data that any other surveyor would need to re-establish the grade at any point.

As our success depends more on the character of the Drain Law than any other one thing, I would like to throw out one suggestion, hoping that it may call out a discussion, though I suppose this is the province of the next paper rather than mine. It seems to me that the great defect in our law, especially for drains of any size, is the manner of working on the credit system, and not raising the money to pay for the work till the drain is located and a tax can be levied on the lands benefited. Thus there are no funds to pay for the work as it progresses, and this makes the work more expensive. But what is worse, non-residents sometimes allow their taxes to be returned, so crippling the treasury as to leave no funds to pay for the work when the orders become due. This causes a sort of uncertainty to hang over the whole business, which very much depreciates the value of orders, and in many cases causes work to be done at speculative prices.

Now if we could have a law similiar to the one in Illinois, or something like the Canadian system, that would allow districts to be formed and bonded for the special improvements, at reasonable rates of interest, pay cash as the work proceeds, and allow the bonds to become due in installments after the benefits have been, at least in part, realized, the now worthless lands would be able to pay their own indebtedness with interest. There is a growing demand for legislation in that line, but just how it should be done I will not attempt to say, for engineers are considered poor law-makers. Last year an attempt was made in the town where I live, and carried so far

as to draft a bill embodying these features, asking for a special act for Sanilac County in view of the large drains we are needing, but it never became more than a "*bill.*"

We live in a wet county abounding in good land (when drained), and are very anxious in this matter. We know that our land is valuable, and can well afford to drain itself if we can only be allowed to go about it in a way that it may be accomplished. And, to say the least, we do not feel grateful when the law-makers in drier sections of the State, not only will not help us in the matter, but will not even allow us to help ourselves.

FRANK F. ROGERS.

NO EXPLANATION NECESSARY.

TOCCOA, GA., February 16, 1890.

F. Hodgman, Climax, Mich.

DEAR SIR:—Prof. Walter S. Wilson, of N. G. A. College, at Dahlonega, Ga., on inquiry by me of him for the best work he knows of on Surveying, sends me your name, as you will see by enclosed letter. Please send me "A Manual of Land Surveying," the book he recommends so highly. He says the price is $2.50; I send check for that amount. If not enough, send the book on and I will remit balance on receipt. Please send the book at once, and oblige,

Yours truly,

LOUIS DAVIS.

DAHLONEGA, GA., February 14, 1890.

DEAR LOUIS:—

Your letter of the 13th inst. was received this morning, and I take pleasure in doing what I can to render you the desired information. The book we used on Surveying was by an English author, Baker, published by McMillan & Co., but the work I am using now as a text-book I consider superior to that one in every particular. It is published by the Engineering Society of Michigan, and is the most satisfactory work, I believe, extant. I purchased it from F. Hodgman, Climax, Mich., who is Secretary of the Society and one of the authors. The title is simply "A Manual of Land Surveying." Col. Price says it is a book that every lawyer should have, as it has the Supreme Court decisions, collected and classified, on every conceivable point that has ever been in dispute before the courts concerning boundaries. Practical suggestions to young surveyors are full, and the theoretical part of the work is in good keeping with the other excellent features.

With many kind wishes for your success, I am,

Your true friend,

WALTER S. WILSON.

To Hon. Louis Davis, Toccoa, Ga.

N. B.—Price $2.50.

The Above Tells its Own Story.

OUR LAWS ON DRAINAGE.

THIS subject may seem anomalous to many members of this Society. There must be others, however, to whom, like myself, it has a practical interest as surveyors.

In our county, and I presume the practice is general, I find it to be the custom of drain commissioners to rely upon the surveyor for advice and assistance in making the necessary papers. As the surveyor's pay for his work depends entirely upon the collection of the drain tax, and this drain tax is based upon the regularity of the proceedings, it may not be amiss to direct your attention to some of the essential points most frequently overlooked.

With a very intricate drain law (I will not say elaborate, for that would at least imply consistency) to work under, and one which no two lawyers will scarcely construe alike, it is theoretically expected that a man who never had to do with law or law forms, aided by defective blanks, will successfully wiggle through the intricacies of the Michigan Drain Law. The court has held that the commissioner cannot pay an attorney out of the drain fund for advice or services, in court, or otherwise;[1] that the forms prepared by the Attorney-General are a sufficient guide; and yet hold drain proceedings fatally defective when they comply with these same forms.

As a prelude, a short history of our drain laws may not be uninteresting or devoid of curiosity. The first Act which I find is in the Territorial Laws of 1819,[2] which authorized the Supervisor "to dig in the highways" and lands adjacent thereto, "such gutters, drains, and ditches therein" as shall be sufficient to carry off the water "with the least disadvantage to the owner of the land," and provided a penalty for filling them up. This Act evidently contemplated that no drainage was necessary except for the benefit of the highway; and the Act of the Legislature authorizing the Supervisor to enter lands was the only right of way then and for many years after, deemed necessary. This Act was embodied in one short section of a dozen lines.

In 1827 the Territory was evidently becoming settled, and something more than highway drainage was needed. In this year it was provided that in case the land was situated so as to be "*conveniently* drained," and the parties could not agree as to how much each should dig, the fence viewers might set

1 Zink *vs* Board of Supervisors, 36 N. W. 73.

2 Volume 1, page 453.

off to each his portion and assess damages for non-performance.

The first drainage Act of the new State was passed in 1839.[1] Any person who deemed it necessary to open a drain through other lands than his own, could have a jury summoned, *ex parte*, who should view the premises of the obstinate party; if, in the judgment of the jury, the damages would be more than the benefits to be derived from the drain, the party applying therefor paid the difference, and in any event, the costs of the proceedings. He could then enter his neighbors' lands "with his servants, teams, carriages, and other necessary implements," and proceed to dig the drain *at his own expense*.

In 1847 an Act[2], supplemental to the preceding, was passed, authorizing the appointment of three County Commissioners "to superintend the draining of such low lands and marshes as do injuriously affect the health of the inhabitants." This Act occupies only two and one-half pages and is but a crude attempt to force unwilling parties to ditch. The Act is historically interesting as first creating the office of drain commissioner, and of authorizing or attempting to levy an assessment for benefits. It contained no provisions for condemning land for right of way, nor were any made until 1861.

In all of the Acts up to 1869, the drain law applied only to lands that could be "*conveniently* drained;" and from the idea of *convenience* probably arose the popular notion that drains could only be laid out in, or following a natural watercourse or swale.

Passing on to the later Acts, I will merely say that our first lengthy drain law was passed in 1869, when the county commissioners were reduced from three to one; that in 1871 the office of township drain commissioner was created, and that our present system was passed in 1885.

My desire was to point out the crudity and ignorant simplicity of our earlier laws. Drain litigation must have been unheard of in those days, and the inhabitants were much more peaceably inclined than at present; for under the later decisions of our courts, not a single drain could have been forced through under those old laws. As a matter of fact, I find but two cases reported prior to 1870; while now, scarcely a term of court passes but what one or more drain cases are disposed of. I shall now call attention to some of those errors, in their order, that should be guarded against.

1 Session Laws 1839, page 153.

2 Act 104, Session Laws, 1847, page 164.

JURISDICTION OF DRAIN COMMISSIONER.

1 The township commissioner has no jurisdiction to lay a drain extending into, or affecting another township.[1] Nor have township commissioners any jurisdiction to act jointly,[2] as our last legislature made the appointment of a county commissioner mandatory, this is not now likely to occur.

2. The township commissioner has no jurisdiction in or over an old county drain, though the proceedings had by county commissioners were illegal, and the entire drain and lands to be affected thereby, are in one township.[3] It cost one of our commissioners about $400 to find this out. Neither can a drain be re-located or re-established in the line of an old drain illegally laid out.[3][4] Nor can a drain be deepened and widened, in effect, on a petition to clean out.[5]

There yet remain a number of questions as to jurisdiction that are not settled.

1. Under whose jurisdiction is an old drain, wholly within one township, originally illegally laid out by county commissioners, and then later illegally acted upon by township commissioners?

2. Has a commissioner a right to lay a drain across another drain already established?

3. Under a petition to widen and deepen, or clean out, can you also incorporate a prayer to straighten or extend?

These are questions that frequently arise, but as to what answer our court might make to them, I would not hazard a guess.

PETITION.

The petition is the basis of authority to act,[6] and is a much more important paper than commissioners or applicants suppose.

It must show that the signers are freeholders.[7] From the inference of three decisions,[8] it must also state that the proposed work is "necessary for the good of the public health," though this may be waived by acquiescence.

Just how definitely, under the decision, the petition must describe the drain, is uncertain. Under the old drain law, the

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1 Drain Com'r *vs.* Baxter, 57 Mich. 127.
2 Hubbell *vs.* Robertson, 65 Mich. 538.
3 Zabel *vs.* Harshman, 42 N. W. 44.
4 Tomlin *vs.* Newcome, 38 N. W. 315.
5 Harbaugh *vs.* Martin, 30 Mich. 234.
6 Kroop *vs.* Foreman, 13 Mich. 144.
7 Frost *vs.* Leatherman, 55 Mich. 33.
8 Butler *vs.* Supervisor Saginaw County, 26 Mich. 22; Kinne *vs.* Bare, 36 N. W. 672; Gillett *vs.* McLaughlin, 37 N. W. 551.

decisions were conflicting, and really required the petition to be based upon the minutes of survey.

Our court has held, under the law of 1885, that it is sufficient to give the termini and general direction.[1] But the court has also repeatedly held that the petition could not leave it to the commissioner to determine distances or direction.[2] Just where the line lies between these two principles does not yet appear.

Our custom has been, especially where there was likely to be a contest, to survey the drain first, and then incorporate the minutes of survey, in full, in the petition.

THE SURVEY.

The survey of the drain must include a description of the land to be taken as definite as would be necessary for a deed.[3] Not only must the commencement, terminus and courses of the drain be accurately given, but also the points of intersection with the lines of every owner;[3] and the width, depth and grade of the drain. It must furnish the data to be acted on by special commissioners or a jury.[4]

These data should not be left for the map and profile to supply, because they must appear at every stage in the Probate Court, and be found there after the proper papers have been returned to the drain commissioner. These data, which the court has held ought to be present, should not, therefore, be confined to the map and profile.

In my own experience, I have used a form like the following:—

Minutes of survey of Coppernal Drain. Commencing in N. E. ¼ of N. W. ¼ of Sec. 8, T. 5 S. R. 8 E., 30 links west of N., S. ¼ line and 4.50 chains N. of the S. line of said description. Thence running as follows:—

Sec.	Course	Distance in chains.	Grade. in	Cut.	Bench. .....feet.
0				2.16	
1	South	2.50	20	4.51	W. Oak 5
		2.00	to S. line of	N. E. ¼ Sec. by R. Kerr.	8, owned
2	"	2.50	20	4.00	
a	S. 86° E.	1.00			
3	S. 50° E.	1.50	"	3.90	

a = angle.

1 Gillett *vs.* McLaughlin, 37 N. W. 551.
2 Null *vs.* Zierle, 52 Mich. 540.
3 Mathias *vs.* Drain Com'r, 49 Mich. 465.
4 C. M. & C. R. R. *vs.* Sanford, 23 Mich 418.

The map and profile could be duplicated from these data as easily as from the original field notes. While the surveyor may think that the commissioner should be able to take his own data from the map and profile, practically, he will find but very few who are able to do so.

In the survey of a drain that is to be deepened and widened, I would suggest that the minutes of survey also show the present width and depth of the old drain; else how can the exact quantity of additional land to be taken be determined?

ORDER OF DETERMINATION.

The main difficulty with this paper is to get the drain commissioner to set out the minutes of survey in full; he is generally content with describing the center line of the drain only.

PROBATE COURT.

I have now reached the stage which proves fatal to so many drain proceedings, and which renders a drain tax so fallible. Our courts require as great nicety and technicality as in the proceedings of a railroad company to condemn land, and even greater; for while the railroad company condemn the land of but one owner at a time, the drain commissioner must condemn an indefinite number, and a mistake on one piece vitiates the entire proceedings.

As my paper would be much too lengthy to tell all that is required, I shall only touch on those points held necessary by our courts, and either entirely omitted by our drain law or else hinted at so vaguely as to seem unimportant.

1. The drain law makes no provision for citing those parties before the court who have released the right of way. Yet it is necessary, and their lands must be described.[1]

2. The commissioner must show not only that he has not obtained the entire release of right of way, but that the parties in interest refused to give it;[2] and the application may be opposed on the ground that all have not been asked to release.[3]

3. It must not only describe the lands, separately, to be affected by the drain, but must describe the land to be taken for the drain itself as definitely as in a deed.[4] To save repetition hereafter, I will add that this same accuracy of description must appear in the order appointing special commissioners or jury, or venire to summon jury, in the oath to the jury or special commissioners, and in their return or award.[4]

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1 Stackhan *vs.* Drain Com'r, 39 Mich. 168.
2 Morseman *vs.* Ionia City, 32 Mich. 283.
3 C.M.&L.S.R.R. *vs.* Sanford, 23 Mich. 418.
4 Chapman *vs.* Drain Com'r, 49 Mich. 305.

4. The commissioner must show, under oath, what, when, where and upon whom notice of the citation was served;[1] and in computing time, the day of service and of hearing must be excluded.[2]

5. It must appear that the special commissioners or jury had all the papers before them required by statute, and also proof of service of the citation;[3] and the drain commissioner's report is no proof of service.[4]

The foregoing are some of the difficulties that present themselves on every application; and difficulties, too, that do not appear on the face of the drain law.

I might go on indefinitely as to the errors likely to be made in the apportionment, sale and levy of the drain tax; but here it would practically be of little interest. If the proceedings for condemnation are regular, there will be few litigations; for the contestant will save only the interest on his tax for one year, when it will be re-assessed. As a matter of curiosity, I will add that there is no appeal from the commissioner's assessment against the township at large.[5]

In making drain papers it will be found much more convenient to attach all descriptions of land, descriptions of the drain and minutes of the survey, as exhibits. By this method a set of blanks can be made that will apply to every drain, whether long or short, without using more space than is necessary, or of unduly crowding matter together.

All blank forms issued by publishers that I have seen, and many of the forms furnished by the Attorney-General, are defective and misleading. None of the blank petitions contain any reference to the public health. In the published blanks, the space for the description of the drain is much too small and generally lead commissioners and applicants to the conclusion that a very short, general description is sufficient. The same objection applies to all blanks wherein the minutes of survey should appear. The result is that nothing but general descriptions of the drain appear in the proceedings. There is no provision in any of the blanks for bringing parties into court who have released the right of way. The commissioner had better throw away his published blanks entirely, for all proceedings through the condemnation of land.

As I have been calling attention to some of the blind features of the drain law, perhaps a short criticism upon it would

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1 Bennett *vs.* Drain Com'r, 56 Mich. 634.
2 Milton *vs.* Drain Com'r, 40 Mich. 229.
3 Milton *vs.* Drain Com'r, 56 Mich. 634.
4 Lane *vs.* Burnap, 39 Mich. 736.
5 Gillett *vs.* McLaughlin, 37 N. W. 551.

not be out of place. If any of you have had occasion to work with it, you must have felt that it was open to criticism in many places.

If we must have farmers for drain commissioners, and they of all others should be the best qualified to make an assessment of benefits, some provision should be made whereby they can employ counsel. It is folly to expect that an election to office will of itself endow a man with the skill that is to be acquired only by long familiarity with law forms.

It is also a serious question whether or not the township drain law is not an evil. It seems as though one man could do the work for less than fifteen or twenty would, to say nothing of the loss of time, trouble, and mistakes involved in "breaking in" so many.

Again, it is a mistake that the county or township at large are in no way interested in, or responsible for, the drain tax. The result is that public officers take no interest in seeing that the commissioner's proceedings are regular, nor do they look very closely into his accounts. The responsibility of the public for the drain tax ought to be as great as for any other tax; and the public would then provide some means of seeing that it was properly levied and collected.

The powers of the commissioner should be more distinctly defined than at present, as I have before pointed out. The provision for the assessment of benefits should be so modified that it could not be made until after the sale of the drain. Judge Sherwood has expressed grave doubts as to the constitutionality of the present provision.[1]

The provision for vacating or abandoning a drain are a curiosity, and if any one can tell what it means, his acumen would be indeed keen.

The drain law, in fact, is a heterogeneous mass of provisions passed by a legislature who seemed to have very little idea of legal rights or forms, and thought that private property and private rights could be invaded without any other process than the mere *fiat* of a session law.

Its practical workings, where lands are owned by non-residents, is about the same as the old law of 1839. The unfortunate resident who is forced to have a drain, "can enter with his servants, teams, carriages and other necessary implements," and proceed to dig the drain at his own expense; for a drain tax, assessed against non-resident land, is very rarely paid and could be still more rarely enforced.

WILLIS BALDWIN.

1 Kinne *vs.* Bare, N. W.

IRRIGATION IN COLORADO.

IRRIGATION is not a new question to the human race, but to the English speaking people and their ancestors, living in countries whose natural rainfall is sufficient to the practice of a successful agriculture, irrigation has not been a necessity, and we, as a people, now meet this problem of irrigation without acquired experience.

Arid lands are not the only lands benefited by irrigation. In countries having an abundant rainfall but suffering an occasional drouth in heat of summer, irrigation furnishes water to the thirsty crops, and even in the most favorable years increases the products of the farm.

That irrigation is beneficial in countries of abundant rainfall, witness the valley of the Po, the garden of Europe. That valley has a rainfall greater than that of Michigan, yet so apparent are the benefits of irrigation, that the irrigated area has doubled in the last thirty years.

Agriculture cannot generally be successfully followed in regions where the rainfall is less than twenty inches. In the United States the line of twenty inches rainfall passes south through central Dakota, western Nebraska, Kansas and Texas. Except for a little area on the Pacific coast, all the region west of the above named line has a rainfall so small as to make ordinary agriculture precarious. The eastern limit of this arid area will be put at 98° by the United States Senate committee on irrigation, making this arid area include about one-third part of the United States—and this by no means the least fertile part, as some of the finest crops in the world are raised here in the heart of the American desert.

EXTENT OF IRRIGATION IN COLORADO.

There are now some 1100 canals in Colorado. The primary canals, meaning by this all those which take water from the river, irrespective of size, measure over 6000 miles. The secondary canals it is impossible to estimate, but as these include all the branches of the primary canals, some of which are forty feet wide on the bottom, it is evident the mileage is very great.

In the short time since Colorado began to irrigate, some 4550 square miles or 3,000,000 acres have been brought "under ditch;" of this amount, taking the State as a whole, probably not far from one-third, or one million acres, is actually irrigated. Considering the fact that Colorado's irrigation development dates back only fifteen years, this is a creditable illus-

tration of the activity of the western people, and the way they are taking hold of the problem of irrigation. In France there were in 1887 only 400,000 acres irrigated. In the valley of the Po there were, in 1882, after six hundred years development, 3,000,000 acres irrigated.

Some canals date back to 1859, more to 1864, but until the Greeley colony settled on the plains in 1871, it was not generally believed that the mesa or uplands were worth anything. There had been a few ditches successfully watering the highlands as long ago as 1864, but these cases were not generally known. The first ditches were small. One ten feet wide on the bottom was an exception. The large ones are all of recent date, most of them having been built since 1880. Some of these have cost hundreds of thousands of dollars, and water thousands of acres of land, and are forty, fifty, or a hundred miles in length.

At no time has there been more activity in ditch construction than at present. The valleys of the Platte and its tributaries from Denver to the mouth of the Cache a la Poudre were first developed, and are the oldest agricultural regions of the State. As mentioned before, the town of Greeley lies in this region. The lower Platte has developed little on account of shortage of water. To supply the area already developed, and to furnish water to the lands rapidly being brought under cultivation, reservoirs for the storage of water are being built in the mountains and on the plains by individuals and by companies. These reservoirs vary in size from 300 acres to small ones intended for a single farm. Reservoirs are destined to play an important part in the future of the irrigation economy of the whole West.

The first problem of the irrigation engineer ought to be that of the water supply. By the laws of the arid region, the first ditches have the prior right, hence any new ditch must get its supply after the rest are satisfied. Some ditches costing hundreds of thousands of dollars have apparently been built without much regard to the supply of water.

CANALS.

These are generally built through lands in advance of all settlement. The projector often buys of the State large blocks of land which, when watered, become very valuable. Though most of the canals are of this character, settlers sometimes, in self-defense, combine to take out a canal for new lands, starting the head above that of the first or old canal, or

they may run a new ditch parallel to the one whose charges they consider exorbitant.

HEADS.

Where the lands are chosen with a view to bringing under cultivation by means of water, it is necessary to first find a suitable location for the head works. A favorable site is all important, so that a headgate and dam may be built without too great expense and with little risk of washouts or of being separated from the stream by sand deposits. Account must also be made of the effect the site will have upon the route below; whether it leads to a favorable course above the bluffs to the objective table land or not. The selection of a site is less important on streams with a rapid fall and firm bottom, than in sandy ones, like the Platte or the Arkansas.

The site selected, the line is then run from the site of the headgate and with the fall which the engineer desires to give, which will vary according to the size of the ditch and the character of the soil, he should not lose sight of the fact that the ditch is to be maintained and that the cost of maintenance depends much upon his judgment in selecting a route.

Sand, extensive fields of which line both the Arkansas and the Platte Rivers, it is always desirable to avoid, as it drifts into the ditches in such quantities as to cause a heavy yearly expense for cleaning, and the loss by percolation or seepage of water is very great.

Flumes and artificial embankments are also to be avoided, if possible, as the former are a constant source of expense in money, water and care, and the latter are subject to the burrowing of moles. The flumes and embankments cause more anxiety to every ditch manager than all the rest of the canal together. If either flume or embankment must be had, then it should be built with proper care, for a break in the busy season means the loss of thousand of dollars to those taking water, possibly the loss of the entire season's work.

Floods are to be provided for, if possible. The plains shed rain like a roof and one learns to respect every insignificant "draw." As an instance I may mention the flume across Horse Creek, on the Henry canal, as shown in one of the smallest photographs accompanying this paper. When I visited it in April there was no water above the sand. The flume, on pile bents 16 feet apart, was high enough in most places to drive a carriage under, yet a sudden storm on the plains in June made this stream a torrent, broke the piles like pipe-stems and wrecked the flume.

GRADE.

The fall needs to be sufficient to give a current with a velocity which will prevent the growth of aquatic plants tending to choke the ditch, but not so great as to seriously scour the channel or be unmanageable in high water. The velocity desired is from two to four feet per second, depending upon the size as well as the grade of the ditch; greater grades may be used in smaller ditches than in large ones. The following table gives the grades of most of the large canals. The tendency, at present, seems to be to lessen these grades somewhat.

Name of Canal.	Grade.	Carrying Capacity.	Width, Feet.	Length, Miles.
Larimer and Weld	2.37	720	30-18	64
High Line Canal	1.76	1184	40	85
Rio Grande	2.45	.....	.....	.....
Citizens	3.0 to 0.5	.....	40	.....
Uncompahgre	3.38	725	.....	32
Henry	2.11, 1.58	.....	30	112
Grand River	1.82	.....	.....	.....
Fort Morgan	2.6, 1.57	340	30	28
Springdale	3.6	115	20	13
Pawnee	1.67	415	35	30
Schneider	3.2	.....	14	.....
Platte and Beaver	2.56, 2	313	30	25
Platte and Beaver Supply	2.11	.....	26	.....
Weldon Valley	2.5	300	20	16
Kiowa and Bijou	1.5	.....	40	50
Prairie	2.7	.....	20	26
Lariat	10	.....	20	4
North Poudre	2.11	.....	.....	.....
San Luis	2.64	.....	34	50
Empire	1.67	.....	60	35
Bessemer	1.25 to 3	.....	24	20+
Dolores, No. 2	2.56	.....	25	6
Amity	1.06 2.11	.....	35	.....

CROSS SECTION.

The cross section of a ditch is trapezoidal, wide in proportion to depth. On account of loss by evaporation, it would seem better practice to build the canals narrower and deeper than is the usual practice. The side slopes in natural earth are 1 or 1½ to 1; occasionally, as in the Del Norte and the Citizen's canal, 2 or 3 to 1. In artificial embankments the slope is 1½ or 2 to 1. The excavated earth is generally put

into an embankment on the lower side of the canal. The top is brought to grade with the intention of making the embankment increase the carrying capacity of the ditch. Practice varies in the use of a berm. When used, four or five feet is sufficient. The movement of earth is done with "slussers," or with wheeled scrapers, at a prevailing cost of 9 or 10 cents per cubic yard.

In several localities ditching machines are used for constructing the laterals. The Monte Vista canal company, as well as that of the Grand River, use a steam dredge for cleaning and extending the ditches. These were adapted to the work and were introduced by W. H. Graves, C. E., the engineer of these enterprises. These are said to excavate at a cost of 3 cents per cubic yard.

HEAD WORKS.

These consist of the dam, waste gate, sand chute, and headgates. The dams are as various as their conditions. They do not generally act as a dam proper, but as a dam for diversion of water. On rocky bottoms it often consists of a few rows of loose boulders sometimes filled in with brush. In the sandy streams of the plains they are all deflecting dams only. In many cases they are simply sand embankments, thrown up with a scraper, running obliquely up the stream, so as to have no pressure to withstand. Every flood washes them out, but they are easily rebuilt. One photograph shows the dam of the Platte and Beaver canal near Fort Morgan, which is the only permanent structure worthy the name on the lower Platte. It consists of a double row of piles eight feet apart, driven at least one or two feet into bed rock, which is 8 to 14 feet below the surface. Each row of piles is sheet piled, each plank being driven to bed rock. The upper piles are 1½ feet above low water. The space between the piles was excavated for three feet and filled with one foot of brush, and two of stone. The dam is 832 feet long and the headgate cost $12,000.

The Platte, it may be said, is a very peculiar river, dry at one point and a little way below a lively stream of water. The sands are generally saturated with water. A dam like that of the Platte and Beaver is intended to intercept the underground flow and bring it into the canal. In the mountains some solid dams are built, as the photograph of the one on the Big Thompson shows.

SAND CHUTES.

In many places the sand is carried with the current. It is not in suspension, but the current rolls it along the river bottom, where it soon fills the headgates and upper portions of the canal. Many preventive devices are tried, but none, so far, are completely successful. The one that appears to do best work, is to keep a flash board below the headgates proper. This causes the sand to fall in front of the gates, and when the deposit has acquired a certain depth it is drawn out by opening the waste gates.

THE WASTE GATES.

The waste gates, if any, are generally supplied with flash boards. Several photographs show them in connection with the dam.

HEADGATES.

The headgate forms, in general, the most important and expensive structure of the ditch. It is built always of wood, though the time is not far distant when we shall follow the example of Italy and build of the stone which is so abundant everywhere. The headgate consists of piles, surmounted by heavy timber, securely braced to withstand the pressure of the water. Aprons should be used in all such structures, though sheet piling is frequently found instead. The gates vary from 3 to 6 feet, clear opening. A good type is that of the Del Norte canal in the large photograph.

FLUMES.

Examples of flumes in the High Line canal in Platte Canyon, 2640 feet long and 28 feet wide, 7 feet deep, grade 5.28 feet to the mile. Also one of similar construction on the same canal over Plum Creek. The latter is some 1800 feet long. It consists of bents of eight piles each 18 feet apart, the piles 6 feet, 3 inches apart. Mudsills 12x12 inches and 48 feet long made of three pieces. The posts are 10x10 inches, mortised into sill and cap. The piles were mortised into the sills, but now the practice is to drift bolt entirely, that costing less and the pile lasting longer. Other views show the excellent Fort Morgan flume nearly half a mile long, the flume near Lamar, one on the Henry canal, etc.

A blue print of the Del Norte, now called the Rio Grande canal system, is inclosed as an illustration of a canal system. This is probably the largest canal in the United States. Starting near the town of Del Norte, at the point where the

Rio Grande enters the San Luis valley, it skirts the foot hills and passes out into the valley. Its course is nearly at right angles to the river, as the river is in the highest part of the valley. It secures its supply of water by damming a branch of the Rio Grande and turning the water down its headgates. A screen made of piles and some distance in front of the headgate, keeps out all floating timber.

The headgate consists of ten gates raised by a screw worked by a wrench. The canal at the head is 65 feet on the bottom and carries 5½ feet of water. The side slopes are 3 to 1, making the width at the water line 98 feet. Four miles from the head it is bifurcated, the large branch being 42, the small one 38 feet wide. Each of these branches gives rise to various laterals, which have been built by the company. These are generally 10 or more feet wide. The length of the main canal is about 50 miles, of the laterals 150 miles. A study of the map will show the unusual character of the country, which is very uniform and slopes from the river. The ditches follow the section lines entirely. All the region between the two branches may be watered from either branch. As an illustration of the evenness of the country, it may be mentioned that one canal runs 26 miles on a section line.

Many other points regarding irrigation and construction it is desirable to mention but lack of time and space prevents. Had it been possible to have had them drawn in time, detailed plans now in my note book of dams, headgates and flumes would have been sent you. L. G. CARPENTER.

Prof. Greene.—"Two or three matters occurred to me as the paper was being read. There is no doubt that the farmers of the West wish the matters of irrigation should go as far as possible, but I think that a great many of these constructions must be of a very temporary nature. It seems to me that though very satisfactory now, there will be in the future considerable expense for repairs. Of course it is to be said that if they were built of stone the work could not have been carried to so great an extent, and there is no doubt structures in the future will be more permanently constructed.

"Another point is in reference to the right of riparian owners. It would seem that where irrigation laws are in force it may happen that one party may have the right to take all of the water from a stream and appropriate it to his own use. That is quite different from the rights of riparian owners in this State and those living near the head waters of a stream would have the best chance."

Mr. Forster.—"A good deal of this is hinged in the mining laws."

Mr. Hodgman.—"It might seem at first thought that the question of irrigation is of little interest to us in Michigan, but to me it has an interest in two ways. First, the great irrigation works of the West are already furnishing employment to some of the members of our society, and are opening out a wide field for the employment of engineelrs in the future Second, I have great interest in whatever will tend to make more prosperous the people in our own State, and I am very confident that the conditions now exist which will make it profitable to irrigate a very considerable amount of our lands right here in Michigan. We are subject to periodical drouths by which our crops are greatly lessened and many times ruined entirely. There is a great deal of land in Michigan so situated with reference to the streams, that it can be easily and cheaply irrigated. Take, for instance, the land in the valley of the Kalamazoo in my own county. There is a tract of land from half a mile to a mile or more wide, extending for from 25 to 30 miles, in that county, which could readily take the water from the river for irrigating purposes. In addition there are numerous tributaries, small spring streams, which never fail, emptying into the river all along the valley. These streams are admirably situated for purposes of irrigation, and I believe that in many cases the small expense required to turn them so as to utilize the water would, in some of our dry seasons, be repaid by a single crop. I had opportunity a few years since to become quite familiar with such small irrigation works as would be required in the case I have mentioned, and it may be of interest to the members of the society to know a little more of the details of how the work is done. The parties wishing to irrigate their lands go up stream to a point sufficiently high to get the necessary fall. How far that will be depends on the fall in the stream and the hight of the valley above it. Having found this point, a ditch is started down stream and gradually leading away from the main stream. The ditch follows very nearly on the level contour line, only dropping enough below it to give the necessary flow to the water. For a small ditch which is only expected to water two or three small farms, the line is marked out by stakes stuck along at short irregular distances, and then when the ground admits of it, a back furrow or ridge is turned up with the plow. Then on the uphill side of the back furrow the ditch is cleared out and opened with the spade or shovel; the dirt which is taken out being used to build up the banks. The

water in the ditch is above the surface of the land adjoining, held there by the banks thrown up. On the downhill side of the ditch is the furrow made by the plow in turning up the back furrow. This is cleaned out to be used as a channel for the water to run in when required. The land to be irrigated, after being sown or planted, has little furrows made all over it running up and down the slope from the margin of the ditch. These are made by a tool made something like a corn marker, with the teeth about a foot apart. It is made from a small log from 3 to 10 feet long, according as the surface is rough or not, with pegs driven in to make the furrows. The fields after being furrowed, resemble a field just drilled into wheat. When the land is to be watered, two little dams made of a few shovels of dirt are thrown across the plow furrow, which parallels the ditch, at a distance of 2 to 10 rods apart. Then an opening is made in the bank of the ditch; the furrow between the dams fills with water and overflows, the water running down the little furrows or drill marks. A man keeps along with the water as it flows and removes lumps of dirt or any other obstructions which may prevent the water from finding its way down any of the little furrows. When the ground is sufficiently watered, the opening in the ditch is closed and another strip watered in the same way until all is done. I have crossed fields in Utah that had been irrigated, where I would sink nearly to my knees in the mud at every step. In many cases these irrigating ditches furnish the farmer all the water he has to use, and the man and his wife, his horse and his pig all drink from the same ditch. I had sometimes to do the same or go without water."

Mr. June.—"This matter of irrigation in Michigan comes home to us in Osceola county, where we have a good deal of land that might be irrigated that is nearly worthless without it. One man irrigated a patch of potatoes last year and got a big crop, when all the rest were nearly a failure. Sylvan township is somewhat flat and it is the only township that has done anything with drainage, let alone irrigation. I should say that about five miles of ditch have been put in for the purpose of draining land rather than wetting it. The water of that ditch could all be used profitably, and I see that this may amount to a good deal here, as well as in the West."

Prof. Greene.—"It is suggested that irrigation might be a good thing for some parts of Michigan.

"You cannot irrigate a country unless you have water. And you cannot get water unless you get rainfall, and if the rainfall becomes so little that crops will not grow that is the

end of it. In the West the water comes from the accumulation of the snow on the mountains, enough to carry them through the summer, and yet sometimes there is not enough to satisfy the country. We have seen statements in regard to the subsidence of the level of the great lakes, that vessels carrying a certain draught could not pass. Attention has also been called to the fact that the smaller lakes have been going down. I have been interested somewhat with regard to my water supply, so I have collected some facts which I have put on paper in the form of a diagram. Some notes as to rainfall are taken by the State Board of Health.

		At Ann Arbor.
In 1877	35.25	
In 1878	38.06	
In 1879	36.35	
In 1880	41.88	
In 1881	43.21	40.36
In 1882	37.25	36.22
In 1883	40.91	35.27
In 1884	37.02	.....
In 1885	35.82	35.14
In 1886	32.16	20.6
In 1887	.....	28.65
In 1888	.....	26.52
In 1889	.....	23.34

"Ann Arbor lies on a gravel soil which rapidly absorbs water. Trees put out their leaves and grow, and in the latter part of the summer they suffer from drouth. But all this don't bring the rainfall.

"If that continued through a series of years, irrigation would do no good, for you would have no rainfall. If we could have our rainfall in the summer instead of in the winter, as we have it now, something might be accomplished.

"You can't supply a place with water where you don't have rainfall enough to supply the demand. I think that the precipitation will increase, and I expect to get back to the time when we will have plenty of water."

Mr. Forster.—"It seems to be on the increase."

Mr. Hodgman.—"I did not wish to be understood that all parts of Michigan can be irrigated, or that it would pay to irrigate everywhere if it could be done. But I am very sure there are many very considerable tracts of land in the State that can be profitably irrigated from spring streams that are no more uncertain in their supply of water than are the streams of the West."

Prof. Carpenter.—"In connection with Prof. Greene's remarks, I would say that I have just come from a State where the condition has been the reverse of what they have here. In New York they have had 72 inches of rain since last May. While our farmers have suffered from drouth, they have suffered from wet. In places the streams have left their beds and run across fields and roads, cutting channels and doing great damage."

Mr. Hodgman.—"That is what I would call running irrigation into the ground."

Prof. Carpenter.—"We have three wells at the college and during the dry time it was thought they would not hold out; but they have. This indicates a head somewhere not affected by the drouth."

Mr. Wells.—"In Wexford county is a tract known as Briar Hills which lies about 1200 feet above Lake Michigan. Below them are agricultural lands lying about 500 feet above the lake, and still further west another tract of about 200 feet elevation. In the Briar Hills many spring brooks take their rise and have cut deep channels in their way to the lake. A year ago this summer, when it was a very dry season, I noticed that the farmers' crops were parching in the sun and these streams running as full as ever. If the water had been utilized it would have saved the crops for some parts of Michigan."

. . . THE . . .

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F. HODGMAN,

Sec. Mich. Eng. Society,

CLIMAX, MICH.

AN INDIAN LEGEND.

THIS legend was recited by David Shapanagon, an Indian living at Grayling, Michigan. He speaks broken English, has learned but very few words, and is therefore obliged to make the same word do duty for several different meanings. He is about 70 years old, and has considerable dramatic power. He says that the legend was taught to him when he was a child; that he has recited it many times before large audiences of Indians, and sometimes has received a pony as prize for the best story. He believes it to be true. The writer heard of the legend through Mr. A. B. Valentine, formerly surveyor of Montmorency County, Michigan. Mr. Valentine speaks Chippewa, and had hunted with Shapanagon, and had heard him recite the legend. Mr. Valentine told fragments of it to the writer and referred him to Shapanagon. The writer visited Shapanagon about four years ago, and heard the legend once. Its recital occupied about two hours. It has been written from memory. The salient points are all preserved, but the details are very deficient; this is especially the case in the description of the storming of the Saugee village and the massacre of the inhabitants; here the recital was especially animated. The orator was very dramatic and graceful, but so much depended upon the action and pantomime that all the writer can remember seems very meager. When he says his "*grandfather*" settled in the country of the Saugees, he probably means his ancestors. When he uses the term "*five hundred years*," he probably means a long time; also, when he speaks of "*five thousand men*," he means a great many, a host, a multitude. When he says that "*the chief spoke an hour*," he means that he made a long speech. It is probable that he used these words, because he knew of no other in English, but if he had spoken in his own language he would have given different shades of meaning.

Five hundred years ago the Chippewa Indians lived at the Straits of Mackinac. They had all the land on the other side of the Straits up to Lake Superior; on this side their land came to the Au Sable and Manistee Rivers—(in one place these two rivers came close together, not a mile apart; this narrow place was the boundary). Their largest city, where their head chief lived, was at the Straits of Mackinac. The Saugee Indians lived on the south side of the river, around Saginaw Bay. Saginaw means Sow-gee-naw, or the country of the Saugees. Their largest city, where the head chief lived, was near where Sebawaing is now; they had another smaller city where the three rivers meet at Midland. If any of the Sau-

gees went hunting on the north side of the Sable or Manistee Rivers, then the Chippewas could kill them and scalp them, and there would be no war. If the Chippewas went hunting on the south side of these rivers, and the Saugees could catch them, then they could kill them and there would be no war. One autumn, after the hunting was over, the Chippewas came back to Mackinac to stay all winter. One family did not come, so their relations told the Chippewa chief. He asked all the men that had been out hunting, "Have you seen this family?"

One man said, "Yes."

The chief said, "Where were they?"

The man said, "They were in a camp close by the Sable River, but on their own side."

The chief said, "When did you see them?"

The man said, "Five days before I started to come here."

Then the chief said, "I want you to take twenty men, all swift, and go and find out what has become of this family. If the man is hurt, or his family is hurt, then you help them come here. I make you chief of the twenty men."

Then this man got twenty other men, all swift. They went through the woods, because it was so near winter that they thought there would be wind and rain on the lake, but there was no wind or rain, so they went fast and came to the place where the man's camp had been. The man and his family were gone. He had one kettle made of clay and one stone ax; these were gone too. There was a heap of ashes where his camp fire had been. Then the chief said to one man, "You stay here and cook." He said to the other men, "Stand in a ring around the camp, with your backs in and your faces out; then every man go in the way he is looking. Look on the ground, logs, trees, bushes, in the water, everywhere, to find this family. When you get farther apart, go to the right hand until you meet the man on that side, then go to the left hand until you meet the man on that side, then go back to your own place and go on a little farther, and do so again so that you will look under every tree in the woods. When it gets dark, lie down right where you are, so as to begin hunting in the morning, for we must find this family before the snow covers up their tracks."

That night it rained very hard, because it had not rained any before; all the leaves hung straight down, and the water ran down both sides. In the morning the cook was pretty wet; he walked around, pretty soon he saw that the ashes had sunk down in the middle. What was that! That

must mean something! He went out into the woods and called. By and by a man answered him and said, "What do you want?" Then the cook man said, "I want all the men to come back, I have found something." So one went to the right and told that man, and the other went to the left and told that man, and they told the next man, and so all of them came back to the camp. Then the chief man asked the cook man what he wanted. He said, "Have all the men stand around the ashes, this time with their faces in." Then he showed the chief where the rain had made the ashes sink down in the middle. The chief said, "What is this?" All the men said, "I don't know." The chief told the men to dig. They found that the ground had been dug up before. Pretty soon they found a man's hand; they pulled him out. Next they found the woman, and in the bottom the two children; all of them had been tomahawked and scalped. The chief said, "All of you look and remember what you see, so that we can tell when we get home." Then they got all of the bodies straight, and put clean birch bark around them, and dug a grave for them, and after it was filled up they put four sticks at the corners. Then they started home. The rain turned to snow, but all the men were swift and could go a long time without eating, so they got home. Then all the people asked them, "What have you found?" The men said, "We are hungry." The head chief said, "Give them something to eat." After they had eaten all the people asked them again, "What have you found?" And the men said, "We will smoke." Then the head chief said, "Bring them pipes and tobacco." After they had smoked, the head chief said, "Sit down in a ring, and let your chief man tell us what you have found." So they sat down in a ring, just behind them the men, and farther back the women and children. Then the chief man told the head chief all that they had found, and the other men said it was true. Then the women began to cry. The young men said, "The Saugees did it, we will go and kill them," and they waved their tomahawks and jumped up and down and patted their hands on their mouths and whooped. After a long time the head chief said, "Listen, I don't know who killed this family. It may have been the Algonquins; it may have been the Winnebagos; maybe it was the Saugees; I don't know, we will go and find out." So the young men waited.

* * * * * * * * * * * *

When the spring came, the Chippewa chief told five thousand of his men to get ready and go with him to see if the Sau-

gees killed that family. So they brought their canoes and put two side by side, and covered them over with bark. Then in the middle they had a pole about ten feet high; on the top of this pole they placed a bunch of feathers—some red and some black. There were more than five hundred such canoes, and the chief had the largest one. Some men would sit in the canoes and paddle; some more would stand up on the bark decks and dance. They had feathers in their heads and paint on their faces, and did not wear any clothes except around their waists. All of them had tomahawks and bows and arrows. They did not start until there was no wind, then all of the canoes kept together, and the men jumped and danced and whooped all the time. When the wind blew they went on shore and waited until it stopped. So it took a long time, three weeks, to get to the Saugee city. When they came in sight, a Saugee man saw them and went to the Saugee chief and told him that the lake was getting black. Then the Saugee chief went to the bank of the lake; he heard the whooping and saw the men dancing on the bark decks of the canoes. He told all the Saugee men to come to the bank of the lake, for the Chippewas were coming and wanted something. So when the Chippewa boats got near the shore all the Saugee men stood on the bank. Then the Saugee chief said:—

"What do you want?"

The Chippewa chief said: "We want to come on shore and talk with you."

Then the Saugee chief told the Chippewa chief and his men to land. He made a line that was a little way back in the woods and parallel to the shore. He told the Chippewa chief that his men could stay between that line and the water. So the Chippewas came on shore and drew their canoes up on the sand. Then the Chippewa chief said to the Saugee chief: "We want to eat." So the Saugee chief had plenty of fish and venison and corn brought to the Chippewas, and they ate all they wanted. Then the Chippewa chief said, "Let us smoke." So all of the Saugees sat down on one side of the line and the Chippewas on the other side facing them. The two chiefs were at the upper end of the line facing each other; next to them were the older men; then came the younger men, so that the youngest Chippewa and the youngest Saugee sat facing each other at the lower end of the line. Then the Saugee chief had the women bring him a hard, dry piece of elm wood, and a round hickory stick like a cane. One end was rounded off so that its point was smooth and hard. In the block of elm wood there was a small hole like a cup. The

chiefs stood the hickory stick in this hole; then they took some punk that they got from a rotten log and picked it up fine and put it in the hole around the end of the stick. Then the chiefs whirled the stick by rubbing it between their hands, so. There was a stone on top of the stick to hold it down. Pretty soon the lower end of the stick began to smoke; then the punk caught on fire. This was a good fire because it was new. No one had a chance to put anything bad in it, or say any devil words when they were making it. Then the chiefs lighted a large pipe, the Chippewa chief took one mouthful of smoke and handed the pipe to the Saugee chief; he took a mouthful and handed it back to a Chippewa man, and so the pipe went backwards and forwards down to the end of the line. Then every man took his own pipe and smoked and laughed and talked about common things. Sometimes a Chippewa would tell a story and the Saugee who sat opposite to him would laugh; then the Saugee would tell a story and may be the Chippewa would laugh, but the Chippewa said nothing about the family that were murdered. After one hour, the Chippewa chief stood up and said: "We came to talk to you about something." Then he told the Saugee chief all about the family that had been killed and scalped, and said: "We have come to ask you if any of your men did this." Then the Saugee chief said: "I feel badly. I do not know who killed this family. Maybe there are some bad Saugees who know about this; I will go and see." So the Saugee chief called all his people together and asked them if anyone knew who killed this family. Some of them got afraid and told who did it. There were six of the murderers; they thought they had buried the bodies so that no one would ever find them, but they showed the scalps to some of the Saugees, and these men told the chief. So the Saugee chief came back and said to the Chippewa chief: "We have found the men that killed this family. Now, what do you want?" The Chippewa chief said, "Give them to us." So the Saugee chief had these six men tied so they could not move; then he had them laid on the ground before the Chippewa chief. These men felt pretty badly, but they did not say anything. The Chippewas tied them to three stakes, two on each stake, back to back. Then the relations of the murdered family came first with their flint knives, and each cut off a piece of ear or nose or cheek. Then all the other Chippewa men came and each cut off a piece. Finally when the Saugee murderers were almost dead, the Chippewa chief came and scalped them and had the scalps for himself. Then the Chippewas piled wood around the dead bodies as they hung on the

stakes, and burned them up. All the time the Saugees stood back a little way and looked on. They felt pretty badly but were afraid to do anything, because there were five thousand of the Chippewas, and each man had his tomahawk. The relations of the men that were burned up saw it too, and they felt the worst of anyone. They were afraid to say anything out loud, but said low to each other: "When we get a chance we will kill some Chippewas and scalp them." Then the Chippewa chief said to the Saugee chief: "I want to say something more to you. You have seen what we have done, and know what kind of men we are. If you want to fight with us next year, we will fight with you then; if you want to fight with us next month, we will fight with you then; if you want to fight with us now, *lift up your tomahawk*," but the Saugee chief let his tomahawk hang down. Then the Chippewa chief said: "If you don't want to fight with us, we will get in our canoes and go home. We will hunt on the north side of the rivers and you may hunt on the south side as we did before. We will bury the tomahawk, so, with the handle sticking up out of the ground. Then, if your people kill any more of our people, we can *take it up quickly*. We will go back this one time. If we ever come again, *we will stay*." So the Chippewas got in their canoes and went home. All that year they hunted and fished and nobody was killed.

* * * * * * * * * * * *

The next year a family of Chippewas had their camp on the north bank of the Sable River. A Saugee saw it, who was a relation of the six Saugees who had been burned. He told some more of his relations; they talked together, but did not let the Saugee chief hear them. They said: "We will kill this family of Chippewas, and no one will know who did it." So they killed them and scalped them and hid the bodies in a swamp. When the time came for the family to come home and they did not, the Chippewa chief sent men as before to see what was the matter. After a long hunt they found the bodies and came back and told all the people about it. Then the young men said, "The Saugees did this, let us go now and kill them and scalp them." The Chippewa chief said: "Wait until we are ready, so that we can kill them all." But the young men said, "We are ready now, if the chief is afraid to go with us, he can stay, and we will have another chief." Then the chief called all the men together, and he stood up and talked one hour to them. He said: "We must kill all of the Saugees. All of our men must go. It will take all summer. We must leave

something for our women and children to eat while we are gone. We want some dried fish and venison to take with us. We want more canoes; we want more tomahawks and arrows. It will take one year to get these things. If you go now, there will be ice in the water and snow on the ground before you get there. If you have had nothing to eat on the road you will be weak, and the Saugees will be stronger than you are. I am not afraid. You saw me when we went there before, and took the six men and burned them. You heard what I said to the Saugee chief. If any young man thinks he is braver than I, let him stand up and speak." The young men were ashamed and did not say anything. A good many of the old men stood up and spoke, and at last all thought the chief's way was best. So the chief told all the hunters to dry and keep half of all the venison and fish that they got the next year. He told the men that made canoes, and the men that made arrows and tomahawks, to make twice as many as before, and save one-half; and so about everything that was made. Every Chippewa, man and woman, had to do twice as much that year as ever before. The chief told all the men and women and children not to tell any other Indians what they were doing. So if a Winnebago came to the Chippewas and asked: "What do you make so many canoes for?" the Chippewas would say: "Oh, maybe next year we will go to Lake Superior and fish." So for one year the Chippewas got ready and the Saugees thought that nothing would happen to them. Finally, when all was ready, the Chippewa chief took five thousand men and started. One-half of them went in canoes, and one-half went on foot through the woods. Those that went in canoes were going to Sebawaing, and those that went through the woods were going to Midland. The head chief went in a canoe. He made another man chief of the men that went on foot. He told this chief to get to Midland in just twenty days and begin killing the Saugees at day-light in the morning, He told this chief to have some swift runners go ahead of his men, and if there were any hunters camped in the woods, to kill them, so that they would not run home and tell the Saugees that the Chippewas were coming. He had two canoes, with swift paddlers, go ahead of his other canoes, so as to catch and kill any fishermen, and not let them get away and tell the Saugees that the Chippewas were coming. The men in the canoes went slowly, so as to get to Sebawaing just the same morning that the other men got to Midland. When the Chippewas got to Sebawaing, they found the Saugees all asleep; they got all around the village, and at daylight they all whooped and ran

in. The Saugees did not know what to do. The Chippewas killed them—men, women and children. The Chippewas set fire to the houses. The dogs barked and the Chippewas killed them too. Some of the Saugee men got away and ran towards Midland; half way there they met other men running away from Midland; then all ran towards where Port Huron is now. The Chippewas followed them; if a Saugee man got tired the Chippewas killed him and scalped him. About one hundred Saugee men got to Port Huron and crossed the river on logs or swam. The Chippewas did not follow them any farther and never heard of them again. All of the Saugee women and children were killed, and their dogs and pigs and ponies. When the Chippewas got back to Sebawaing the chief called them all together and said: "This is a good land and there is no one alive in it; if any of you want to stay here you can." So a good many of them stayed, and among them was my grandfather. He and his children always lived there afterwards.

E. S. WHEELER.

A MANUAL OF LAND SURVEYING.

Owosso, MICH., Dec. 16, 1889.

MR. HODGMAN, *Sec. Mich. Eng. Society.*

DEAR SIR:—Enclosed please find draft for your bill short bank exchange. The Manual of Land Surveying received from you some time since, is a splendid book, worth twice its price.

Yours truly,

H. C. MAIN.

Shiawassee County Surveyor.

F. HODGMAN, Climax, Mich.

TRUE EXTERIOR BOUNDARY OF THE TOWNSHIP.

A CONTRIBUTOR to our exchange from the Illinois Society of Engineers and Surveyors, for 1888, advances ideas that I can not endorse.

After a vast expenditure of ink, and some erudition, he comes to the conclusion "*that the boundary, as modified by subdivisional survey lines and corners, is to be regarded as the true boundary line of the township.*"

This interpretation would ignore the following facts in relation to this question:—

1. The principle universally recognized in all the public surveys, that consecutive corners—except in the case of meanders—are to be joined by right lines.

2. That all subdivisional lines of any legal division, are controlled and determined by the boundary lines of such division.

3. That the closing of subdivisional lines at points not in the boundary of the legal division thus subdivided, is anomalous to the fixing of the interior corners; and therefore not subject to the same law.

4. That the closing corner is always described and returned by the deputy-surveyor as being on the boundary line.

5. It ignores the ruling of the Commissioners of the General Land office, in a particular case, "that the township line is also the boundary line of those sections immediately south of it; and that the setting of a corner beyond or short of it does in no way change the place of the boundary line."

6. This interpretation of the law would produce a conflict of interest.

The possessor, say on the north of the boundary line, by this ruling, holds to the original boundary; while the possessor on the south, by the same law, holds to the modified line—thus producing a conflict of interest when the subdivisional lines extend across the boundary, and thereby perpetuating and intensifying the difficulty, the law fixing the interior corners, was designed to obviate.

The anomalous character of this case, as compared with that of an interior corner, is seen in the fact that in the boundary two lines may occur, thereby producing the conflict of interest referred to, while in the interior of the township no such case can occur.

It is evident that the case under consideration was never thought of, much less was it provided for by the law-makers,

when they provided that the lines and corners, as returned, should be regarded as the true lines and corners. As a consequence, to consider the law as applying to this case, would be a stultification of the law, an act that courts and law-makers are not often guilty of.

As before shown, the ruling of our Illinois friend would give to each of the two contestants the same legal right to the same piece of land.

Now, when we can find an intelligent court in the United States that will eject either of these parties to make room for the other, we will admit that there is some merit in the logic of our Illinois friend.

Until that time come, I do not know what can be done with a corner that has been set beyond or short of the line, more than to use it as a means of finding where the section line intersects the town line, at which place the county surveyor may proceed to plant a *new corner*, though, perhaps, he may not disturb the old one. H. C. PEARSON.

BOTH'S SECTION-LINER.

CORNELL UNIVERSITY,
College of Civil Engineering.
ITHACA, N. Y., March 16, 1890.

A. C. BOTH, *Civil Engineer.*

DEAR SIR:—This college of Cornell University has had in use, or in its collection of special instruments, every variety of "Section-Liners" it has been able to procure.

I have no hesitation in saying that the one purchased of you a few weeks ago is the best one yet brought to my notice, and is simple, reliable and satisfactory for its purposes.

The use of all other Section-Liners has been abandoned here, and yours is exclusively employed. I am Sincerely Yours,

E. A. FUERTES.

Director Coll. Civil Engineering.

See Advertisement, page 29.

HARDENING AND TEMPERING OF STEEL.

MR. HODGMAN, secretary, came to me last Friday, and wanted to know if I could not read a paper on Steel. I told him the time was rather short and that I could not give much of a paper, but perhaps I could give a little talk on the subject; but to do anything like justice to it, would require a large amount of space and time.

What I will try and do in this brief talk is to give a few hints on the subject from the best firms and experimenters, together with a few illustrations of work done by myself.

Oftentimes engineers and mechanics are away from good steel workers, and have a cold chisel, drill or other tool they want tempered. Of course, there is the country smith somewhere in the county who will undertake to do it. If he happens to make a good job once, he will tell you that he can temper anything; but the chances are where he succeeds once he will fail a dozen times, and then he has no end of abuse for American steel. "It is poor American steel. If I just had a good piece of English steel, I could make a chisel that would skip anything." But if you should get the best English steel, he would not hit it every time, and, of course, when he didn't, it would be a "poor piece." I find the word *English* has a wonderful effect on steel, or rather has had in the past. A man in Cleveland, who sells all kinds of steel, told me this summer that he had one firm that he could not get to use a piece of American steel. He got the firm to let him take a skilled steel worker in and make some tools, show them how to work the steel and what it would do, then the men would not use it. The proprietor was satisfied that the American steel was good and would like to use it, but no persuading would make the men do so. The steel merchant said he would put an English name on the steel. This was done and the steel did most excellent work. "Quite English, you know." This steel was, as I am glad to say, from the Detroit Steel Works of this city. The best tools I ever used were made of Detroit and Crescent Steels.

The Crescent Steel people, of Pittsburg, are taking untold pains with their steel, and for myself, I would rather have it than any English steel I have ever used.

WHY STEEL HARDENS.

One word about why steel hardens. I have been asked this question often, but have had to say I could not tell, nor have I been able to find out. If we did know, it would probably be an explanation to some of the curious freaks it takes. I will

give, however, what is generally thought to be the best theory I believe. Still this is merely a theory. Now, the theory is this:—

Steel is said to be composed of molecules of iron held in a fixed correlative position by virtue of the molecular forces, and between contingent molecules there exist certain known physical pores. It is conceived that carbon is absorbed and retained within these pores by force of attraction exerted by molecules of iron and atoms of carbon. The molecular force of attraction is opposed by another force which is due to heat, and the balance of these forces is called the resultant force. These forces exerted by continuous molecules being balanced in each physical pore, each force represents a distinct resultant force. Therefore the resultant forces may vary in different pores. If so, the absorption and retention of carbon will not be uniform. Any variation of temperature in any part of the structure will cause a corresponding change in the resultant forces in such pores as are subjected to such changes, and as this force attracts more or less carbon in proportion to its intensity, it follows then that the change of temperature in any part of the structure causes a redistribution of carbon. Hence, it may be concluded that, though the molecules of iron are fixed in a correlative position, the carbon is transitive, subject to be drawn from pore to pore as the resultant forces exerted at each point change.

Now the heating of the steel has the effect of dilating the metal and giving to the molecules a mobility necessary to enable them to unite; the sudden cooling bringing them rapidly together causes combination. Caron regards the hardening of steel as the result of this combination. Others consider that the molecules are in a state of agitation and that their edges (if we can speak of them thus) are moving in all sorts of directions and that the sudden cooling fixes them in this position.

Now, these are theories advanced by some very prominent men and I have given them to you about as they are found in Janes on The Steel Manufacture.

PROPER WAYS OF HEATING STEEL.

The open forge fires, such as are used in blacksmith shops, are the most convenient ways of heating simple pieces of steel; but, if the piece is long or of much value, this is not a good way of heating. If you have no other means, then bank your fire with fresh coal, place a piece of iron, say two or three inches in diameter, inside the fire, then get it to burning enough to coke the coal a little. As

soon as this is done, pull the iron out and you will have a hollow space for heating the steel, and if you work the fire slowly, the steel will heat evenly. Another good way is to bank a piece of steam pipe in the fire and put the steel in it. This I think is best, as it protects the steel from the action of the fire.

A good way of heating very valuable pieces, where we are quite particular about an even heat, is to take and melt lead in an iron dish over the fire. The lead should be covered with charcoal to prevent the surface from oxidizing, then the lead can be heated to the red heat and the steel placed in it. This gives a very even heat.

Another way of heating is in a gas fire. Where it is possible, this is perhaps the best way, if we have cheap gas. I will give one very crude fire that may be of service to engineers out in the woods and away from forges. Take a little good dry wood and start a fire; when the coals begin to form, place your drill or other tool in them. The drill will heat red hot; then with one hammer as an anvil draw out the drill with another hammer, and temper as I will describe later on.

We have shown how to heat steel, but we also have to employ some element to do the chilling or hardening. The quicker we chill a piece of steel the harder it is. The hardening may be done either with solids, liquids or gases. Most of the hardening is done, however, with some form of liquid. But I am inclined to think that gases can be used more than they have been.

The solids used are sealing-wax, tallow, lead unmelted, and other substances. The liquids used are very many; the most common I will give: water, salt and water and mercury. So far as I know air is about the only gas used, although Jarolimich, superintendent of works on the Danube, has shown that the hardening of steel has been done in steam. He also states that hardening of steel has been very poorly understood, and that it does not harden in the manner generally supposed. His experiments show that steel may be hardened in hot water, boiling oil, melted led and melted zinc, when it is cooled to 752° F.

These facts are rather surprising when hardened steel will soften on being heated to about 400° F. However, if the steel is heated somewhat above that of the melted zinc, say 150°, and plunged into the zinc, it will harden, but if left in the zinc it again softens. We can conclude that the hardening of steel does not depend altogether on being plunged into a very cold

liquid, but depends on the rapidity with which its heat is taken from a high degree to a lower one.

Now the question might be asked, Why not use warm liquids and heat to correspond? Steel hardened in very hot liquids is not very hard and cannot be from the fact that the hardness does not depend merely on the conductivity of heat by the liquid, but also on its power to absorb latent heat, and having a low boiling point. Now I think we come to a very important point in the hardening of steel. If we wish it very hard, use a liquid which will carry a large amount of latent heat and conduct heat well also. Then we can keep our steel at a much lower temperature, thus keeping the maximum stiffness with the minimum expansion.

The reason steel cracks on being hardened is because it is expanded by heat and when plunged into water the outside cools and shrinks, while the inside is still expanded, which causes cracks; but if we keep the expansion low, the steel may be elastic enough to keep from cracking.

I have found where it is possible it is well to have a hole in large pieces so as to cool the center first.

One word about water. I have had men say to me that they could not use the steel on hand, that it was bad, etc. One case I remember of in particular, where the workman could not temper the steel without heating it very high, and then it would crack. I tried it myself and had bad luck. I tried again, with no better results, and made up my mind that the steel was not good.

The next day, however, I tried another piece tempered in condensed steam and it worked all right. The trouble was the hard water. Sometimes if you do not remove the scale from steel, it will not harden well.

When a moderate degree of hardness is required and the piece is very valuable, it is well to use oil; this leaves the steel a little tougher than water does.

It is always well to harden only a little harder than we need to for the work it is to do, as we can keep the heat low. However, it is not possible to harden steel just to the right degree without we have a large number of pieces to harden of the same kind, size and out of a constant steel; so it becomes necessary to make the steel a little harder than we need and then reduce the hardness by applying heat. This is what is known as the tempering process. If the surface of the steel is polished after it has been hardened and is heated to about 450° F. there will appear on the surface at first a pale yellow, afterwards all of the colors of the spectrum down to dark blue.

The first is very hard and the last is very soft. This forms what is known as the tempering scale, and all degrees of hardness lie between the two extremes.

We have thus far found out how to heat steel, what to use in hardening, how to harden, and how to temper. Yet something should be said about the degree of heat. This is a point which I find men most ignorant in, and is the cause of untold trouble.

Tool steel should never be heated above a white heat and is better if it is not heated above the red heat, as the carbon at the high heats has too much affinity for oxygen and passes off.

I will give you one of the most important ways of ascertaining what heat to use. It was discovered by the Crescent Steel Works of Pittsburg.

"We take a bar of steel of ordinary size, say about an inch by a half, heat six or eight inches at one end to a low red heat, nick the heated part all around the bar, at intervals of half to three-quarters of an inch, until eight or nine notches are cut. This nicking is done at a red heat to determine the fracture of the nicks. Then place the end of the bar in a very hot fire, leaving the balance of the bar so much out of the fire as to heat it chiefly by conduction. Heat the end of the bar in the fire to white hot, or until it scintillates, and allow it to remain until the nick farthest from the end in the fire is not quite red, and the next barely red. Now, if the pieces be numbered from one to eight, beginning at the outer end,—

"No. 1 will be white or scintillating.
"No. 2 will be white.
"No. 3 will be high yellow.
"No. 4 will be yellow or orange.
"No. 5 will be high red.
"No. 6 will be red.
"No. 7 will be low red.
"No. 8 will be black.

"As soon as heated as above described, let the bar be quenched in cold water, and kept in the water until quite cold. After cooling, the bar should be carefully wiped dry, especially in the notches. An examination of the different parts by the file will show the following, if high steel has been used:—

"No. 1 will scratch glass.
"Nos. 2, 3 and 4 will be excessively hard.
"Nos. 5 and 6 will be well hardened.
"No. 7 about hard enough for tap teeth.
"No. 8 not hardened.

"In breaking off the pieces, which should be done over the corner of an anvil, and the pieces caught in a clean keg or box to keep the fractures clean and bright, it will be found that

"No. 1 will be as brittle as glass.

"No. 2 will be nearly as brittle.

"Nos. 3, 4 and 5 will break off easily, each a little stronger than the other.

"No. 6 and 7 will be very strong, and much stronger than No. 8 or the bar unhardened.

"Place the pieces in the order of their numbers, fitting the fractures. Then 'up end' each, beginning with No. 1 and following in the order in which they lie, and the result will be the series of fractures, as shown in Plate XXII, each differing from the other.

"No. 1 will be coarse with a yellowish cast, and very lustrous.

"No. 2 will be coarse and not quite so yellow as No. 1.

"No. 3 will be finer than Nos. 1 or 2, and coarser than No. 8, and will have a fiery lustre.

"No. 4 will resemble No. 3 in color and lustre, with somewhat finer grain, and will be coarser than No. 8.

"No. 5 will be of about the same size grain as No. 8, but will have fiery lustre.

"No. 6 will be much finer than No. 8, will have no fiery lustre, will be hard through and very strong. This is what is called refined by hardening.

"No. 7 will be refined and hard on the corners and edges, and rather coarser and not quite so hard in the middle. This is about the right heat for hardening taps, milling tools, etc., the teeth of which will be amply hard, while No. 8 illustrates the original grain of the bar.

"In almost every case the bar will crack along the middle to the refined piece (No. 6). In the illustration the crack shows very plainly in No. 4. This crack has never been known to extend into the refined piece, although the experiment has been many times repeated."

From this experiment the following conclusions are drawn concerning the effect of heat upon steel:—

"1. (a) A difference in temperature sufficiently great to be seen by the color will cause a corresponding difference in the grain. (b) This variation in grain will produce internal strains and cracks.

"2. A temperature so high as to open the grain, so that the hardened piece will be coarser than the original bar, will

cause the hardened piece to be brittle, liable to crack and to crumble on the edges in use.

"3. A temperature high enough to cause a piece to harden through, but not high enough to open the grain, will cause the piece to refine, to become stronger than the untempered bar, and to carry a tough, keen cutting edge.

"4. A temperature which will harden and refine the corners and edges of a bar, but which will not harden the bar through, is the proper heat at which to harden taps, rose bitts and complicated cutters of any shape, as it will harden the teeth sufficiently without risk of cracking and leave the body of the tool soft and tough, so that it can yield a little to pressure and prevent the teeth tearing out."

To test a piece of steel, take and draw it out into a cold chisel of about 30° or even 20°, then sharpen to 60°; if it cracks in this process, it is of no use; but if not, heat to the proper heat as indicated by the Crescent people's method, and plunge into water at 60° or 70° F. and draw the temper to a blue. If this chisel stands up well on wrought iron, it is very fair steel, but if not, it is probably poor. It is well, however, to try a second or third test. If it breaks, it may need to be a little softer, or if it turn, it may be made a little harder; but, if it will not temper hard enough to keep from turning without breaking, the steel is of no use. C. G. TAYLOR.

W. K. MUIR, Pres. and Gen'l Mangr., Detroit. S. D. MILLER, Secretary, Detroit.
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MEANS EMPLOYED IN RUNNING A STRAIGHT LINE.

THE most important instrument used in running a straight line, is a well-adjusted transit. There are so many text-books which give full directions for adjusting instruments, that that matter will not be discussed here. Next, and equally essential, is a firm, solid foundation upon which the transit is to stand. Swamps and marshes are not the only places where the shifting weight of the transit-man will throw the telescope out of line sufficiently to produce one of those eye sores known as "swings." Made ground in cities and villages, which has been formed by making the original hole a dumping ground for brush and rubbish, and then covered with a thin layer of earth for grass to grow, or holes filled up with slabs, listings, saw-dust and shavings, then sodded over, are often more unstable than swamps. In such places it is difficult to drive stakes for a good foundation. Even if they can be driven down, some part of the incongruous mass will be quite sure to throw most of the weight of a man against one of them. As soon as he changes his position the instrument will be disturbed. A hub should not be placed near a large tree in river or creek bottoms, nor in swamps, as a very gentle breeze will sway the tree enough to shake the ground for a distance of twenty or thirty feet from it.

In a swamp where the muck is more than ten inches deep, it is well to drive three stakes. They should be driven in the direction which the tripod legs will stand when set up, for obvious reasons. Sometimes the muck is so deep, that when large, long stakes are used, one position must be maintained if the transit is kept in line. In such a case one man should be called back and placed behind the transit. When both have found a position where they can move their bodies above the hips, sideways, without disturbing the instrument, the transit-man will turn the vertical hair on the back sight, reverse the telescope and allow the man to place the color pole. The operation should be repeated several times—the men changing sides—to insure accuracy. In the winter time, shaded places should be selected to set up on, especially if the temperature is above the freezing point. Then, the transit must be watched constantly, for it will surely settle off of the tack, and may have to be re-set four or five times if it stands over a hub half an hour.

There are many methods used by different persons for projecting a point in a right line. One, which is time honored, is to have a back flagman hold a color pole over the last

point. This is a good way, provided each one has done his part of the work correctly, but it leaves no backsights standing, so that you can check on them when set up in favorable locations. The back flagman must be skillful and able to hold the color pole perpendicularly over the point. He must not be sleepy, and always ready for business when needed. A man of such qualifications cannot always be found, so backsights, made from small, straight saplings, have been made to take his place. In an open country, these backsights are usually beveled at the top, leaving a ridge about an eighth of an inch wide. The backsight is plumbed up back of the transit, before pulling up, with the ridge placed just back of the eye-piece of the telescope. Through the woods, two pieces of paper, or two pieces of bark, with the light side forward, are fastened crosswise to the backsight with a tack. The paper, or bark, reflects considerable light, and it can be more easily found. The tack, or beveled top, when placed at the eye-piece of the telescope, is the point used in sighting back.

It is well to instruct the head chainman to drill a hole in the ground six inches back of the hubs, to set the backsights in. He should have the color pole placed with the instrument, before drilling the hole, then when the backsight is placed in it, and the tack, or beveled top, placed to the eye-piece of the telescope, you will know that it is plumb.

There is still a better way. Have a man set numerous sights ahead of the instrument. Pieces of card-board or paper can be tacked to fences, small sticks driven into tops of stumps, or ordinary backsights set up. When sights like these are placed as often as every two hundred feet, there will be little chance of error.

A backsight set in the ground, may be pried out of line by a root, or other substance, so slowly that it will not be noticed unless there are two or more fixed points by which the movement can be detected. With so many different kinds of sights, set by the aid of the instrument, any disarrangement of them will be quickly noticed, and can be corrected before any damage is done.

In setting tacks in hubs for transit points, if the color pole is bent or inclined slightly, or if the shoe is not set so that its point is exactly in line with a perpendicular line running through the center of the color pole, the tack will be out of line. When only a portion of the color pole can be seen, it may be held awkwardly and the tack placed considerably to one side.

With several sights to look back at, errors in transit points will be discovered, *because you have two or more points in a straight line to check on.* If only one backsight is used, or if a color pole in the hands of a back flagman is held over the last tack, the point taken from either is assumed to be correct. The transit point over which the instrument is set is also assumed to be correct. Now if the assumptions are true, there will be a straight line.

We have seen how a backsight set in the ground may be pried to one side. The back flagman and his color pole are liable to the same errors that may occur to the head chainman in setting transit points, so it is a risk to assume anything.

The conclusion that I have reached in this matter is, that it is best to use the back flagman in setting as many sights as he can put in, and put the cost of his color pole toward making a perfect one for the head chainman.

The head chainman, or the man who carries the color pole, selects places to set up on, and gets the transit points, is a very important factor in running a line. Nearly as much depends upon him for accuracy and speed as upon the transitman. He should be thoroughly drilled in everything in his line of duty. He should be taught to hold a color pole perpendicularly, by clasping it lightly between the thumb and forefinger of both hands, and the hands held above the head. The point should be lifted a little above the ground or hub. He must keep it squarely in front of him, and move his body the same distance that he does the color pole, when getting a point. As soon as the "All-right" signal is given, let go of the pole. It will fall vertically and make the point plain. If the pole is held to one side it is apt to have some uneven pressure given which will make it incline more or less.

It is quite certain that a man cannot stand awkwardly and hold a color pole accurately. He must be able to judge of the firmness and stability of the ground to set up on. He must select places where the longest sights can be had, and in running through timbered country, he should select transit points where the ground begins to ascend or descend. If any deep ravines or gullies are to be crossed, he must select points to get across them with the least possible chopping, and without having to set up on the steep side hills. He must know something of the reflection of light, so that when he goes to select a point, he will not get on the shaded side of a big tree, but get where the most light comes in through the leaves. A small limb cut out of the way will often let in a wonderful amount of light, or a white handkerchief spread over the

chest, or a light colored straw hat held in the right position, sometimes reflects enough light to show up clearly, objects which before were blurred and indistinct. In fact, he must be a man of gumption and equal to any emergency.

But he cannot do good work unless he is provided with a good color pole. It should be made from a good piece of straight-grained timber. I have found white, or Norway pine to be the best. It is fitted at the bottom with a shoe made from gas pipe, with a steel point welded on, and finished by turning down in a machine. The shoe ought to be of sufficient weight to bring the center of gravity within two feet of the bottom, so that it will have a greater tendency to hang vertically when held up.

The sizes of color poles vary according to the place where they are used. If one is dressed down with planes to a six or eight-sided stick, tapering slightly toward the top, it will keep straight much longer than a stick turned in a lathe. I do not know of any way, however, that one can be made which will never warp or bend. The shoe should be made of sufficient size to receive the stick, without dressing it down to go into the socket. Several trials will have to be made before they can be fitted to each other correctly. When finished it should be thoroughly tested, to see if the point of the shoe has been set in line with the center of the pole. To make this test, suspend a plumb bob from a point in a ceiling, and mark on the floor the point carried down. Fasten a string in the center of the top of the color pole and suspend it from the same point. If the point of the shoe covers the mark on the floor it is all right. Prying with a color pole should be prohibited.

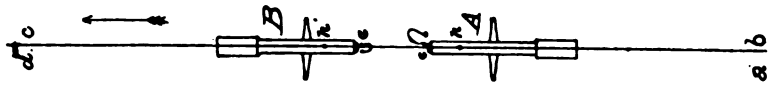
These remarks about the head chainman and color poles may seem extended and to deal with tiresome details, but it is exasperating to a trained man to take a good transit into the field, use care in keeping it in adjustment, and then have all of his pains go for naught, on account of a "chump" or a crooked stick.

A friend of mine exhausted his patience and his supply of men, trying to find one who could do the simple act of holding a color pole plumb, and as a last resort, had one made with a shoe so heavy that a man with ordinary strength could not hold it in any other position.

Sights should be equal in length if possible. None of them less than 200 feet, and of as great length as signals can be seen and understood.

Hard winds and refraction make work very uncertain. Clear, cool days are the most favorable for fine running.

A man may select the best transit, a well-trained head chainman, a perfect color pole, and use every precaution in running a long tangent, and when he has finished, may be greatly vexed and mortified to find instead of a straight line, he has run an arc to a circle, which has a long radius. If he starts out to review his work by repeating the work at each hub, he may discover no inaccuracies there, but can only see that it is a curve, as he looks at a large part of it at a time. I can only explain this in the following way: Some instruments have an eye-piece which is so large that when the eye is moved back and forth at right angles to the line, the cross hair appears to travel across a fixed point. Most men stand on the same side of the line and use the same eye, when looking either backward or forward. Now, suppose a man stands at the right side of the line and uses his right eye, and



has a transit of this kind. In the drawing let A represent the telescope pointed backward toward the backsight, and B the telescope reversed over the same point and *b c* the line of collimation, *h* and *h'* the cross hair. Standing on the right side of the line, the eye will naturally be on the right side of the line of collimation. When looking at the backsight *a*, the telescope will be clamped when the cross hair covers the point, but instead of the telescope pointing toward *a* it really points to *b* in the line of collimation. So when the telescope is reversed and the man endeavors to set the point *c*, he will set the point *d* which is in line with his eye *e* and the cross hair *h'*. The distances from *a* to *b* and from *c* to *d* are slight and nearly equal, and the points *a* and *d* are points in a curve, tangent to the line of collimation. If the work is reviewed from hub to hub this error will not be noticed. Only when a number of them are seen on one side of the instrument will the curvature be apparent. There is also a personal error which enters into line running. It is also noticable when two persons run levels over the same line. The error is quite uniform and may of itself produce a slight curvature.

It would seem then that if a man ran a straight line of great length without error, he will do well to divide the credit about equally between his skill and good luck.

GEORGE L. WELLS.

Mr. Sears.—"I would like to ask Mr. Wells whether he relies upon his transit in getting a straight line without getting a double center. The only way to get a straight line is to reverse the transit and take a second point and get the center."

Mr. Wells.—"I should do this if the transit were out of adjustment, but I keep my transit in adjustment so that it would make no difference."

Mr. Hodgman.—"I would ask Mr. Wells, in the case he mentions, where there is an apparent motion or traveling of the cross wires, whether he noticed if the lenses in the telescope were properly focussed."

Mr. Wells.—"It was fixed on the object."

Mr. Hodgman.—"If the eye-piece was not correctly focussed on the cross wires, it would cause the apparent traveling of the wires."

Prof. Davis.—"I think you will get rid of that trouble if you test the eye-piece."

Mr. Sears.—"If he always takes double centers with care and skill he will be all right."

Mr. Hodgman.—"That is a sure way. I seldom do it, because I keep my instrument in good adjustment. I use backsights with a fine point, and leave them all standing where set. It often happens that from some point I can get a range back over quite a number of these points. Then if the instrument is the least bit out, I detect it at once and apply the correction. It is very seldom that I run a line for any considerable distance without an opportunity of this kind for checking up the adjustment of the instrument, as well as testing the accuracy of the line."

Prof. Davis here exhibited some light transits made by Buff & Berger, of Boston. "One thing the gentlemen will want to know is the price. They cost just about as much as a larger instrument. The work is finer on them. They will do just as good work as the larger instruments. An instrument of that size has been used in extensive triangulations, with accurate and satisfactory results."

Question.—"How close do they attempt to read them?"

Prof. Davis.—"Mine is graduated to read to half minutes. That instrument you have weighs 5½ pounds. The tripod weighs the same. For one, I have got through carrying about a twenty-pound transit on my back. I could tell you any number of stories in regard to the work of this little instrument. It is large enough for any ordinary use."

Mr. Wells.—"How about leveling with the transit?"

Prof. Davis.—"I must express my want of confidence in the level made on the transit instrument. For ordinary surveying, for sidewalks, etc., the level on the transit may be used."

Mr. Sears.—"Mr. Davis must excuse me if I am prejudiced against these small instruments. They are badly agitated by the wind. They have been lightening the tripod, and now they are lightening the instrument. I would like to see a man manipulating this in a cold day. It is well enough for a young man to get down to a fine point, but I prefer a large instrument."

Mr. Hodgman.—"Has Mr. Sears had any personal experience in the use of these light instruments?"

Mr. Sears.—"I have not. I would not use one of them."

Mr. Hodgman.—"Well, I have. From 1868 until 1881, when I went into the Denver & Rio Grande Western Railroad Survey, I used the heavy transit exclusively. When I went there I sold my instruments to the company. It was a hard place on instruments and I had a good many different ones in my party of all sorts of makes. The transit which did the best service and was every way the most satisfactory of any I had, was the lightest one of all, and was made by Young & Sons, of Philadelphia. It got to be pretty well known along the line, and not a little strategy was used by different transit men to get that instrument. In 1882 I purchased a Gurley light mountain transit, which I sold last year, and I now have another of the same make. I find by eight years' use of these instruments, that I can do as accurate work with them as I could with the large instruments. So far from being unstable, they stand more firmly in the wind than the large ones. They have just as broad a base of support on the ground, with very much less surface for the wind to get hold of. After fourteen years' use of the heavy transits and eight years of the light one, I have got so lazy that I would not take a heavy transit as a gift, and be obliged to carry it, if I could buy a light one at present prices. I have more confidence in the level on the transit than Prof. Davis

has. I used to feel just as he does about it. But I have always had a good deal of mixed surveying to do where I had to both run lines and take levels. This led me to make a number of extended and careful tests of the level on my transit, and I found, as the result of those tests, that the levels on the transits that I tested were plenty good enough for any work I have to do. Hence, I do all my leveling now with my transit and save lugging an extra instrument about the country when I have both kinds of work to do.

The following figures are taken from the notes of one of these tests. A line was run from Barron Lake to Niles with a Gurley Light Mountain Transit, leveling by stations with the transit as the line was run. It was then leveled a second time by stations with a 20-inch Gurley Wye Level. The following table gives comparative heights as taken by the two instruments:—

Station.	Height by Transit.	Height by Level.	Station.	Height by Transit	Height by Level.
0	100.00	100.00	175	75.17	74.91
25	115.03	115.39	200	74.10	74.17
50	109.36	109.25	225	72.73	72.77
75	106.84	106.90	250	65.18	65.31
100	94.86	94.93	275	34.66	34.92
125	86.95	87.39	279	32.04	32.32
150	77.65	77.98			

Mr. Davis.—"Mr. Sears has referred to his prejudices. Just as long as Mr. Sears is above ground we will respect those prejudices, and if he is going to lug a big instrument, we are going to let him, and the more years he lives to do it the better we will like it."

Mr. Wells.—"I used a small transit like Mr. Hodgman's and a large one side by side on the same work, and in closing there was a difference of about 2′ in favor of the larger instrument."

Prof. Carpenter.—"Other things than the size of the instruments may have caused the difference."

Mr. Hodgman.—"It is not so easy to read the smaller graduations, but I use a magnifying glass and have no trouble."

Prof. Davis.—"If the verniers are made correctly on the small instrument, there will be no difficulty in reading them."

YPSILANTI WATER WORKS.—ABSTRACT.

I HAVE been engaged during the past season in planning and constructing a system of water works for the city of Ypsilanti, and while there is nothing originally new or novel involved in the construction of these works, yet I think there is very much that is well worth the attention of all persons professionally or otherwise interested in such public improvements.

The plan of works adopted at Ypsilanti is based on the pumping and elevated reservoir service combined, both ordinary service and fire service being furnished direct from the street mains. There is a very broad distinction between the system of works I am here describing, and what is commonly called the pumping to stand-pipe system. Of all the water-works systems, where pumping is required, I claim the Ypsilanti system is the best in all respects.

It is superior to the pumping and open-earth-reservoir system, chiefly from the fact that the water in the perfectly enclosed elevated reservoir cannot deteriorate from exposure, as in the open reservoir. It is superior to the simple so-called direct-pressure service, both in economy and efficiency of service. In the direct service, an instant stoppage of our pumping machinery, and the entire service is dead. In no case can the service from such works exceed the simple capacity of the pumps. Nothing can be stored up for use in time of necessity, while to be prepared to meet extraordinary demands, we must keep expensive reserve machinery in constant readiness for use.

It is impossible to pump water economically in the direct service, because we never know what we have to do. At one hour of the day we may be called upon to run our pumps at their full healthy capacity, at another hour of the same day, perhaps only one-fifth of this service will be required, yet we must be ready at all times to meet all calls as they come. With our elevated reservoir we are perfectly prepared at all times for all emergencies. We can run our pumps at all times at the same speed, and under the same pressure, working to their full economic capacity, regardless of the current consumption; whatever excess of water there may be pumped, above the ordinary current consumption, will go to the reservoir, there to be stored to carry the night service when the pumps are idle, or to meet any demands that may temporarily exceed the pumping capacity.

To illustrate, we are building works for a small city where a half million gallons of water per day will be the maximum consumption for ordinary service. If we are to have a fire service, as well as ordinary service *direct* from the mains, we must be prepared to meet short calls for fire service, *four times* greater than this maximum ordinary service. If we are working under the simple, so-called, direct pumping plan, having nothing but our pumps to rely upon, then these pumps must be of *five times* greater capacity than needed for our ordinary work, and this excess must always be kept in readiness for *instant use.* The amount of water required for fire service for a whole year, averages less than *one day's* ordinary consumption, yet, to do this *one day's* work on the *direct* plan, we must keep our *four-fold* excess of pumping capacity in readiness for 365 days in the year.

In nearly all our public water-works systems the amount of water running to waste greatly exceeds the amount used for strictly necessary purposes. I think it is safe to say that seventy-five per cent of all the water used, escapes from faucets partially opened and constantly running. These openings are all gauged to give the required amount of water under the *ordinary* pressure; a fire breaks out, and at once the pressure must be doubled, your waste is doubled, and your fire service handicapped. Your pumping machinery is usually not adequate to meet all these demands effectively. Your mains are not large enough to carry this amount of water without a frictional loss that will very seriously impair the efficiency of such service as your pumps may still be able to render. In many cases your water supply will not be adequate to meet all these wants, and wastes.

The stand-pipe cuts so small a figure in water-works construction, considered purely on its merits, that it would not be worthy of any extended notice, but for the fact that the great majority of the people hold such vague ideas concerning it.

The original intent of the stand-pipe, was to provide a relief for the pumping machinery and mains against the shock of suddenly changing pressures. A stand-pipe of proper height, and in size equal to the force main, would serve this purpose as well as one of larger size. Of late years, stand-pipes of much larger size have become quite popular with many engineers. The only added merit these larger stand-pipes possess consists in their added storage capacity, and this is too small to cut any important figure. A stand-pipe fifteen feet in diameter, and one hundred and fifty feet high

will hold a little less than two hundred thousand gallons of water, counting from the ground up, and will cost ten thousand dollars, or five cents per gallon for every gallon of water it contains; if we enclose it, as ought to be done, then it will cost as much more. But only *one-fourth* of this water will do *effective work*, so that this raises the cost of our structure virtually to twenty cents per effective gallon, if naked, or forty cents per gallon if enclosed. Such a structure cannot do fire service longer than thirty minutes without reinforcement from the pumping station, nor can it do good ordinary service long enough to enable us to reduce the working force at the pumping station.

A properly constructed water works, on the pumping and elevated reservoir plan, should consist of a pumping plant of at least double the capacity required by the maximum consumption of the ordinary service, so that the full twenty-four hours' supply can be pumped by working half time, with one set of men, and a reservoir of sufficient storage capacity to carry the ordinary service during the night, and to meet the demands for fire protective service at all times. The reservoir must be placed at sufficient elevation to afford sufficient fire service by the simple gravity pressure of its waters.

In order to secure the best results, the pumping station and reservoir should be on opposite sides of the city, the street main distribution lying between. This arrangement will reduce the frictional loss in the mains to a minimum, and secure the highest degree of efficiency in the service. The pumps and reservoir will be connected directly through the street main distribution, and when the pumps are running, all the ordinary service will be supplied direct, the pumps always running up to their full economic capacity, without any regard to what may be transpiring throughout the distribution, the aim being to pump all the water in ten or twelve hours, that will be required during the twenty-four hours.

Of course the excess of water pumped, beyond the ordinary current requirements, will pass into the reservoir, there to be stored for the night service, and to meet any extraordinary demands that may arise. Should a fire break out during pumping hours, calling for water in excess of what the pumps are delivering, no attention need be given it at the pumping station, as the moment the pumps fall short of supplying the demand, the reservoir will come to the rescue with its reserve power, and both reservoir and pumps will work effectively and harmoniously together. It is now that the importance of a proper placement of our pumps and reservoir will most plainly

appear. If our pumping station and reservoir had been placed in juxtaposition, compelling both to work through the same main, from the same direction, instead of working in harmony and full effectiveness, there would be constant conflict and but half service could be rendered. It would not be possible to establish an effective, frictional equilibrium between the contending forces.

In planning and constructing the Ypsilanti Water Works, it has been my aim to harmonize all these elements, and to develop a service of the highest degree of economy and efficiency, and its natural advantages have been highly favorable to this end. Nearly three years ago I visited Ypsilanti, and made a preliminary investigation relative to the development of a public water supply. I found everything favorable to success. In April last the people voted to bond the city for seventy-five thousand dollars, the money to be used in developing a system of water works; I was employed by the Board of Water Commissioners to plan and superintend the construction of their proposed water works. In the commencement, it was deemed best to only put on about ten miles of street mains, with a small steam pumping plant and an elevated reservoir. Later it was found that an excellent water power, fully equipped for service, was available, and it was deemed best to purchase this water power, and abandon the steam pumping plant part of the plan. The adoption of the water power increased the first cost of the proposed works about twenty thousand dollars. As the work progressed, a demand sprung up calling for a large extension of the street mains, the result being that an additional fifty thousand dollars in bonds were voted, and additional mains were put down, until the total street main distribution reaches nearly eighteen miles. This gives Ypsilanti two and one-half miles of street mains for each one thousand of her population, which is more than double the average of the cities of the United States having water works, and renders her more perfectly equipped in her public water-supply service than any other city in the State.

This liberal provision in the outset has proven wise, and fully justified by the results. The people are more generally satisfied, as the entire city now enjoys the *full benefit* of the improvement, whereas with only ten miles of street mains, as at first intended, only about one-half the city would have been directly benefited. These works start out, from the day of their opening, as a *self-sustaining* public improvement. I think this is the first case of the kind on record.

The plan adopted in constructing the works will account for this. Utilizing our water power, we brought into requisition a temporary pump, and, taking water from the river, filled the mains as fast as laid, the object being mainly to provide water for puddling the back-filling of the trenches, and to furnish fire protective service from the hydrants as fast as set. In sixteen days from the opening of the first trench, we threw fire streams ninety feet high, direct from the mains in the heart of the city, three-fourths of a mile from the pumping station; and in ninety days all the street mains were in place, and the city fully provided with effective domestic and fire-protective service. Soon after commencing pipe laying, applications began to come in for permits to tap the mains for water for lawn sprinkling. This demand exceeded the capacity of the pumpers to meet, and kept in advance until the close of the season. Between four and five hundred connections were made before the close of the season, and before the works were completed and formally opened. Had the Board been able to keep pace with the demand of the applicants, there would doubtless have been eight hundred paying connections with the mains before the works were completed and formally opened. We did not wait for the completion of this branch of the work before starting in on other parts of the work, but commenced and prosecuted all simultaneously.

The water power and buildings of the Ypsilanti Paper Company, located in the southern part of the city, were purchased by the city, and the pumping plant located there. The supply well was located about one thousand feet from the pumping station, on the opposite side of the Huron River, which, running from north to south, bisects the city. This well consists of a circular caisson thirty feet in diameter, constructed of iron and masonry, the sides being impervious, and sunk to the depth of thirty feet, terminating in a stratum of water-bearing gravel. Fifteen feet of hard pan, of such tenacity as to require blasting, overlaid this water-bearing stratum. When the water was reached it overflowed the surface of the ground. This water supply is ample in quantity for the utmost requirements of the city, having been tested to more than three millions of gallons per day, and the quality of the water cannot be surpassed.

The pumps are conneted with this well by a sixteen-inch suction main, running under the river, in the same trench, and parallel with the twelve-inch force main. One and one-half miles from the pumping station, diagonally across the city, is located the elevated reservoir. The ground upon

which this structure is built is one hundred and three feet above city datum.

The reservoir is constructed as follows: First, a substructure of masonry, circular in form, forty-two feet in diameter, and eighty-five feet high is constructed. The walls are of Joliet stone, laid in cement mortar. The outer wall is in true circular form, three feet four inches thick at grade line, and two feet thick at top, or base line of reservoir. There are three parallel walls, at equal intervals inside, running entirely across and intersecting the outer or circular wall. These walls are each of the same thickness and height as the outer or circular wall. The excavation in which the foundation for these walls is laid, is circular in form, fifty feet in diameter, and covered solidly to the depth of six inches with very rich cement mortar. Upon this are laid the footing courses for the walls above. These courses are of dimension stone, laid in terrace form, each course being sixteen inches in thickness, the first course for all the walls being six feet in width, terminating at grade line in a course four feet in width.

Crossing the wall at top, in parallel courses two feet apart, at right angles with the walls, are steel floor beams ten inches in depth, for the reservoir to rest upon, the walls being built up between the beams, flush with their upper surface. These beams project thirty inches outside the masonry all around.

The reservoir consists of a steel tank, circular in form, forty feet in diameter and twenty-seven feet deep, and resting upon the floor beams and walls of the substructure. A sixteen-inch main connects the reservoir with the street main distribution, and an eight-inch overflow pipe leads to the sewer. This reservoir is entirely enclosed with a structure of wood. This building rests upon a circular plate of steel, bolted to the ends of the projecting floor beams, is circular in form, rises perpendicularly as high as the top of the reservoir, and from this line a dome roof is spread over the whole, terminating in a cupola with glazed windows in each of its four sides. There is two feet of clear space between the outside of the reservoir and the inside of the walls of the enclosure, and twenty-two feet of clear space from top of reservoir to base line of cupola. The cupola is two hundred and fifty feet above city datum, and will be provided with a cluster of electric lights.

The capacity of this reservoir is a little in excess of a quarter of a million gallons, which is thirty-five gallons per capita for the entire present population of the city, and *every gallon* of this water is always available for full, effective fire

service. The full reservoir will furnish six effective fire streams, for six consecutive hours, without reinforcement from the pumps. This reservoir will be ample to render full service to the city for at least five years, after which it can be duplicated on a corresponding summit on the opposite side of the river and city, a central twelve-inch force main leading from one summit to the other. This main is already laid. The present force main from the pumps through the distribution, is twelve inches in size, and runs through the main part of the city on the west side of the river. Five years hence the plan contemplates a duplicate twelve-inch main on the east side. The present arrangement will supply all demands up to that time, and the plan, when fully completed, will be better than if a larger *single* force main had been provided in the outset.

With the plan fully carried out, the pumping station and the two reservoirs will occupy the three points of a triangle about equidistant, with the entire street main distribution enclosed. Under this arrangement we will secure a very high degree of effectiveness in the service, the frictional loss of the water passing through the mains being very small. The street main distribution is so arranged as to give a double-discharge fire hydrant at every street intersection. The mains cross the river five times, giving full service to all parts of the city.

The pumps are power pumps of an entirely new pattern, are triplicate in form, and promise to give an exceptionally high economic duty. Running these works by water power will save much expense.

There is water sufficient all the year to operate the pumping plant, and for nine months in the year there is more than needed. The city will utilize this extra power to run its electric street lighting plant, which is now operated by steam power. The electric plant is being placed in the pumping station, and will be run by the same power as the pumps, when there is sufficient water; when not sufficient water, then by a Corliss engine attached to the same line shaft, being so arranged as to permit of instant change from water to steam, or the reverse. It is estimated that this arrangement will save the city five thousand dollars per year in running the two plants, as compared with running both by steam.

The cost of the Ypsilanti Water Works has been a little less than one hundred and forty thousand dollars. Ten thousand dollars of this, however, should be charged to the electric light plant, and five thousand dollars to the private service

development fund. This will leave the actual cost of the water works, one hundred and twenty-five thousand dollars. The elevated reservoir cost seventeen thousand dollars, which is about six and one-half cents per gallon of its waters. The interest on the cost of these works, and the current running expenses, will not exceed eight thousand dollars per year. The revenue from private rates will exceed this at the end of the third year, and the city council has only to credit the water works an exceedingly low rate for fire-protective service, to provide a sinking fund that will take care of all the bonds issued for the *entire work*, long before their maturity; and this without levying one dollar in taxes to redeem these bonds.

In the construction of the Ypsilanti Water Works, no contracts for work were let, everything being done by day labor.

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PHOTOGRAPHIC SURVEYING.

THE theory or principle of this method of surveying is identically the same as used in plane table work, or, indeed, in any system of triangulation. We must have at least one measured base line, and then we proceed to take angles from various points to the objects to be located, not, however, by actually measuring them as in triangulation, nor by drawing lines toward required points as in plane table work, but by taking photographs which shall include the required objects as seen from at least two distinct points of view. These photographs serve every purpose that is required for making maps, giving not only horizontal angles, but also elevations or depressions, and the location of every object shown on photographs taken from two distinct points of view. All precautions regarding the selection of angles that applies in triangulation or plane table work holds equally true here. If radiating line from different points meet at an acute angle, errors are likely to result—greater as this angle is smaller.

Any method of procedure practicable in plane table surveying is equally serviceable in this. I will, however, describe but one method, that being similar to the one usually used in triangulation. First measure a base line, as *A B*, and also take its bearing, if it is desired to know the bearings of the other lines of the survey. Set up the camera at *A* and sight it on *B* and so as to cover some object toward *D*. If no fixed object can be seen at the termination or limit of view, a flag must be set; this then gives us the angle *D A B*. The next view would include the point *C* and *E*, making the angle *D A C*, if the instrument is sufficiently wide angled, if not it may be divided into two or more views. After taking all the sights needed at *A*, the instrument may then be moved to *B*, then with the instrument sighted on *A*, take as large an angle as possible toward the objects *D* and *E*, and continue until all the objects desired come onto the field of view. The pictures which may be obtained from these different views by a skilled observer,

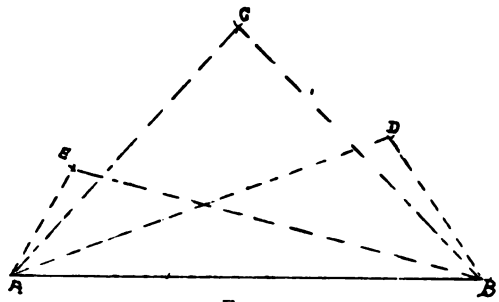


FIG. 1.

with the proper kind of apparatus, will provide accurate information regarding all these various angles. After securing two views on any point its location then becomes known, and the instrument may be moved to that point, after which proceed as in the first instance. Thus the field of operation becomes wider and wider. A practical limitation with this apparatus will soon be found, however, because of the small size of the pictures as compared with the objects, so that distant objects, unless they are very large or bright, can not be found on the picture. This limitation depends entirely on the lens used, the shorter the focal length of the lens, the less the distance objects can be seen.

This method of operation is no doubt comprehended by every one, because it comes directly within the province of the surveyor. The remaining operations involve work heretofore done largely by photographers, and, consequently, are new to our business. I know that surveyors have not been photographers, and at the risk of being tedious, I will describe the essential instruments and processes used in photography, although by so doing I may be going over work very familiar to many of you.

HOW TO PHOTOGRAPH.

The basis of modern photography is the dry plate. This consists of a plate of clear glass, or transparent film of celluloid, covered with an emulsion of gelatine made sensitive to light by the addition principally of bromide of silver. Some of these plates are extremely sensitive, and an exposure even as short as 1-50 of a second, is sufficient to give a clearly defined image. The action of the light changes the nature of the chemicals on the dry plate, somewhat in proportion to its intensity. This change is rendered visible by the application of certain other chemicals called developers. Even after an image is made to appear by the developers, the plate is still sensitive to light, and it must undergo a process called fixing before it can be exposed in white light. Red and orange light have little or no effect on these sensitive plates, and, consequently, they may be examined and handled by light passing through a ruby or orange glass. The necessity of thoroughly protecting these sensitive dry plates from the light when in transit is now seen. Various devices termed dry-plate holders are used for this purpose. They are so made that a shutter can be taken from in front of the dry plate and replaced, when the dry plate is in the camera, without exposing the plate to any light. If a dry plate were to be exposed in the open air, diffused light would act on it and no image would

appear, the whole plate would appear black after developing. There must be some means of concentrating the image desired and shutting off the effect of any other light. It is found that this may be done by a dark box with a small pin hole opposite the dry plate—quite creditable pictures have

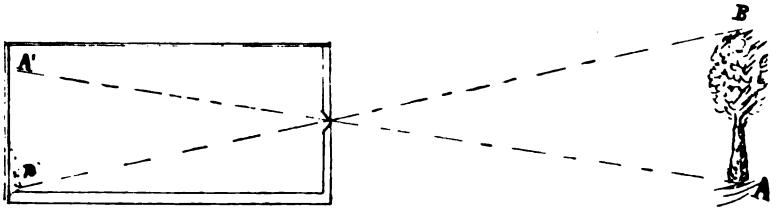


FIG. 2.

been taken in this way. This would be the simplest possible form for a camera. It would need no focussing arrangement; the size of the picture would depend on the length of the box, and the sharpness of the picture on the smallness of the hole. The principle of action is shown in the sketch, by means of which it is seen that the image is inverted as compared with the object. To cut off side rays of light the box should be painted black on the inside. Such a camera, though it might be accurate, would be exceedingly objectionable in practice; since if the hole were small enough to give a sharp image, even the most sensitive dry plate would be exceedingly slow, because of the reduced amount of light. From five to ten minutes exposure would probably be required.

The use of a lens virtually enlarges the hole for the admission of light and still concentrates the rays of light, so that pictures may be taken very rapidly. The use of a lens for photographic purposes is more trying, more difficult to satisfy perfectly, than for telescopic or microscopic purposes. A very short discussion will, I think, make this point clear to you without entering into any abstruse calculations. First, however, we will consider the commercial camera.

THE CAMERA.

The camera for photographic purposes consists simply of a box, the length of which can be changed at will, usually by connecting the back and front with a flexible bellows. In the front is arranged the lens, and in the back is a place fitted to receive the dry plate-holder. When not in use, a ground glass screen takes the exact position of the dry plate when in the act of taking a picture. The image of the object to be taken

is thrown on the ground glass, and by shutting off the side rays of light by throwing a blanket over the head, it can readily be seen. The length of the camera can be changed until each portion of the picture appears sharp and distinct, at which time it is in focus and ready for the picture. When the camera is level, the ground glass must be vertical. If it is necessary to incline the camera upward or downward, the ground glass must be inclined but little from the vertical. This condition requires a swinging back around a horizontal axis, technically called a single swing back. The back is also sometimes swiveled so as to swing on a vertical axis, technically called a double swing back. Both these attachments will simply make a surveyor trouble without ever being of benefit. The angles of his camera should be rigidly at right angles, as the least change of position of the dry plate is fatal to accurate work. One movable feature, and one only, is permissible in the camera for photographic surveying, and that is a sliding front board, by means of which the center of the object glass can be raised or lowered above the center of the camera. The effect is to raise or lower the field of view, through an angle whose tangent is equal to the distance moved from the center position divided by the focal length of the object glass. By means of a table of tangents a scale reading to degrees or even closer can be computed and marked on the front board. Pictures taken under such conditions can be reduced to equivalent horizontal pictures.

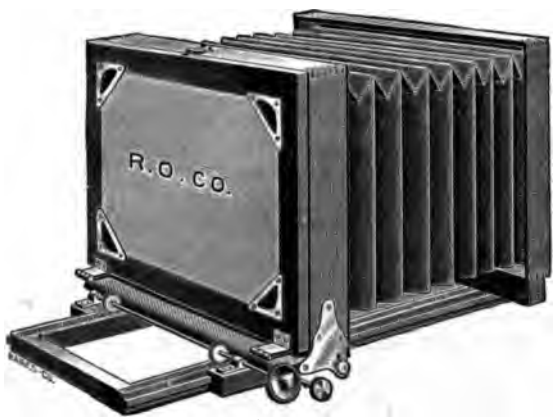


FIG. 3.

After considering the requirements and methods of testing lenses, the adjustments required for the camera will be considered.

THE LENS.

Let us consider for a moment the action of a lens in producing an image. Let *K L* be a double convex lens, *A B* an

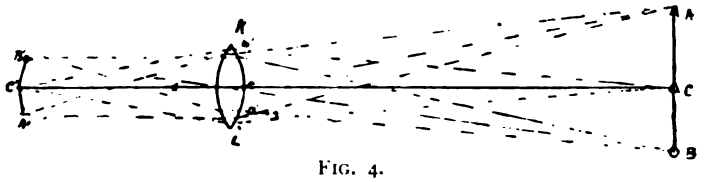


FIG. 4.

object in front of the lens. Rays of light from every point of this object radiate and completely cover the lens. Thus, for instance, from the point *A* in the object, rays of light strike every point of the object glass, for instance *a' e' c'*. These rays of light in passing through the lens are bent toward the perpendicular, and in leaving it they are bent away from it. The effect of this is to converge all the rays of light from the point *A* in the same general direction, or if the lens is perfect, to unite them at same points *A'*. In a similar manner the rays of light from *B* unite at same point *B'*, those from *C* at same point *C.'* We thus have the images of all points of the object formed somewhere back of the lens. These points may or may not be in the same plane, that is the point *C'* may be further from the lens than either the points *B'* or *A'*. In the case of a camera this condition would exist when we get a perfect image in the center of the picture and a confused one along the edges.

A study of the sketches makes another thing evident: as the distance to the object increases, the image approaches the lens, until when the rays of light are parallel the image is at its nearest position to the lens, or is said to be at its principal focus. This is readily seen in the above diagram; the parallel rays of light *A* and *B* meet at *F*, those from *C* meet at *C'*. Since the focus continually changes its position with reference to the lens, as the distance to objects vary, so is the image to be found in various positions. Now then, we find with this change of focus of the center, a change in the relations of the focal positions of the extreme points. That is, we might grind our lens to bring the points *A' B' C'* in the same plane for one position of the object, but we should find that a change in the position of the object would necessitate a new focus and consequently a different adjustment of these relations. The perfect lens for a camera is then a mathematical impossibility, as it involves a changeable form to the lens for each position of the object.

Possibly it needs such a lens as nature has furnished in the organ of sight, which acts under conditions more nearly like these of the camera lens than any other instrument.

That this limitation is less important for the telescope is seen at once, in the fact that we are interested in that case only with the center rays, or those near the center, and we put in stops or diaphragms to prevent any possible injury by interference of the side rays.

Having only the center portion of the image, the error in the shape due to different positions of focus at extreme edge and center, entirely disappears. Achromatic lenses, or those which do not separate the chemical rays of light, as is well known, by forming a lens of two kinds of glass, are even more important in a camera than in a telescope, since these chemical rays act with very different intensity on the sensitive plate.

We will call the first error described above aberration, and will say that it can be much lessened by using only the central portion of the lens to transmit light. This is done in the case of a single lens by placing a diaphragm, with a hole of a definite size in front of the lens. The diameter of this hole is generally some even divisor of the focal distance of the lens, and a large variety of diaphragms is provided with each instrument.

The error of aberration is also reduced by using two lenses in the object glass, placed a short distance apart. As seen from the diagram, the effect of the two lenses is to doubly refract the rays as compared with a single lens. This has the effect to bring the focus nearer the lens, and also reduces the distance between extreme positions of focusing. The effect of this is to reduce the error, or at least make it more nearly uniform, so if corrected at one point it will not be so badly out at others. Thus, with the single lens the focus would be at

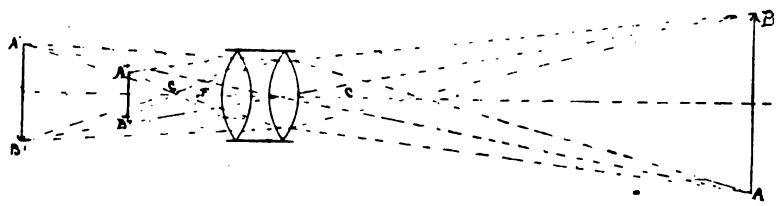


FIG. 5.

A' B', but with the combination it is at A'' B''. Despite this improvement of the double lens over the single one, no maker claims to produce a lens without aberration, unless diaphragms are used as previously described. Then he cannot claim its

entire absence, but that it is reduced to so small an amount as to be invisible and immeasurable, at least with certain stops. This condition makes the lens practically correct. The purity of the glass is of as great or greater importance than the figure of the object glass, as every flaw, change of density or color, in time affects the image. In this respect each one of the past few years has marked great improvements, and it is believed that optical glass is now being manufactured that is nearly free from the defects mentioned. In regard to lenses for cameras, the best ones are probably produced in Europe. Dallmeyer of London, and Suter of Berne, are the two most celebrated makers. There are, however, a great many lenses made in this country, many of which are of great excellence. I have myself tried two of American make, the Morrison lens, manufactured by the Scoville Co., and the Bausch & Lamb, manufactured at Rochester, N. Y. In both instances the errors from aberration were less than could be measured. Either of the above makes, if as good as the ones tested by myself, would do satisfactory service in photographic surveying.

TESTING LENSES.

1. Lenses may be tested for aberration by focusing on objects very close and very distant and noting the relative sharpness of the image at the center and edges of the plate. If no diaphragm is used, the best lens made will show some defects, especially if a magnifying glass be used to examine the image. The best test for engineers is to arrange a series of objects at different distances and in different directions from some central station; measure these angles accurately with a transit, then afterward repeat the measurements with the camera. If there is any disagreement whatever, measurable, I should reject the lens.

2. The lenses may be tested for other defects by fastening them in the end of a long tube, with a place for the eye at the other. Make a diaphragm of paper with a small hole so arranged as to be movable and to admit light to different portions of the lens. If the lens is perfect, it will in all cases appear uniformly bright. The last is an important matter if we expect a lens to do satisfactory artistic work.

3. Rotate the lens in a tube; if any shifting of the image appears, the lens is defective, or at least not mounted correctly. This test is much the same as that used to test the line of collimation of a level.

4. Make a photograph of paper ruled in squares like cross section paper, having the photograph as large as can be taken.

If the squares are not of uniform size, or are not perfect in the photograph, the instrument is faulty.

FOCAL DISTANCE OF LENSES.

The focal distance of a lens is the distance at which the image is formed from the center of the lens for distant objects, and must be accurately known before angles can be measured from the photographs. Unless this distance is extraordinarily great, the focal distance of objects forty rods or farther away will not differ sensibly from those at an infinite distance. Hence the determination of focal distance for parallel rays can be used without sensible error for ordinary measurements. The focal distance is always given by the manufacturer of a lens; but so far as my experience goes, their statements are not accurate, and perhaps are intended only to be approximately true. At any rate, it will be necessary to accurately determine the focal distance for each individual lens. It may be done as follows:—

1. Approximately, by taking the lens from the camera and obtaining the focus of the sun on some screen. The distance from the center of the lens to the screen will be an approximate focal distance.

2. Draw a heavy black circle on white paper, say six inches in diameter. Arrange this on the side of a small box so as to remain vertical. Level the camera, and set its center the same hight as the center of the circle. Move the box toward or from the camera, keeping the paper parallel to the ground glass of the instrument, until the image and object are of equal size, in which case the distance from the ground glass to the object is four times the focal distance. This method is applicable only with a camera that will extend about twice as far as the focal distance of the lens.

3. Use the same method, but make the image one-half as large in linear dimensions to the object, in which case the focal distance is equal to 2-9 the distance between image and object. This can be used with nearly every camera.

4. Use the same method, making the image one-third the linear diminsions of the object; in this case the focal distance is equal to 1-5 the distance between object and image.

5. The focal distance may be computed from data furnished by measuring the size of the object, its distance and the corresponding size of the image on the ground glass, by direct proportion, as will be explained hereafter. If n be the

ratio of object to image, the focal distance equals the distance between image and object multiplied by the fraction $\frac{n}{(n+1)^2}$, or for great distances $\frac{1}{n}$.

MATHEMATICAL CONSIDERATION OF THE FORM OF LENSES.

At this point it seems necessary to investigate some of the relations existing between the form of lenses, size of objects and size of images, in doing which demonstrations will be given for the different cases cited under the methods of finding the focus of a lens.

Because of the difficulty of construction, the forms for surface of lenses are movably spherical. Rays of light in passing through them apparently all intersect at a point termed the optical center of the lens. Considering aberration zero, parallel rays from any point all meet at the same point. This point is in the plane of what is termed the principal focus of the instrument, and its distance from the optical center is the focal distance of the lens.

In the figure

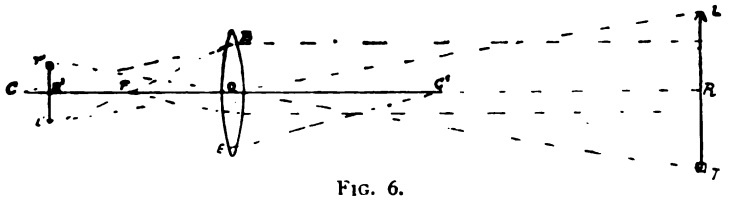


FIG. 6.

Let $C\ B=r$, radius of one surface of lens.
Let $C'\ E=r'$, radius of inner surface of lens.
Let F= principal focus or focus of parallel rays.
Let $F\ O$=its distance to $O=P$.
Let O=optical center of lens.
Let $L\ T$ be any object and $L'\ T'$ its corresponding image.
Let $R'\ O=p'$, its focal distance.
Set $R\ O=d$, distance of object to center of lens.
Let $M=\frac{\text{sine angle incidence}}{\text{sine angle refraction}}$=index of refraction.
Then from any treatise on physics we will take the formula

$$\frac{1}{p}+\frac{1}{d}=(m-1)\left(\frac{1}{r}+\frac{1}{r'}\right)$$

No. 1. For parallel rays the object is at any definite distance $\therefore d=\infty\ \frac{1}{d}=o$

Put $F=p$ $\frac{1}{F}=\frac{1}{P}=(m-1)\left(\frac{1}{r}=\frac{1}{r}\right)$

No. 2. Focal distance of parallel rays. For this case use symbol F instead of P

$$F=P=\frac{2r^1}{(m-1)\ (r+2^1}$$

r

No. 3. When $r=r^1$ $F=2\ (m-1)$

For glass used m varies from 1.52 to 1.56 equals about 1½. Hence p is equal approximately to v, or O F is nearly equal to C F. Since the rays of light intersect at O apparently we have from similar triangles $L\ T : L^1\ T^1 : : O\ R : O\ R^1$ letting $L\ T=b$ and $L^1\ T^1=i$.

No. 5. $b : i : : d : P^1$.

$\frac{b}{i}=\frac{d}{P^1}$ or the relation of the size of objects to image varies directly with the distance from the object glass. To consider the case when objects shall equal image—in this case $b=i$ $\therefore$ $d+p^1$ and $\frac{1}{p^1}$ equals $\frac{1}{d}$ or $\frac{1}{p}+\frac{1}{d}=\frac{2}{p^1}$.

Hence from No. 1 $\frac{2}{p^1}=(m-1)(\frac{1}{r}+\frac{1}{r^1})$ But in No. 2 we see this is the value of $\frac{1}{P}$ $\therefore$ $\frac{1}{F}=\frac{2}{P}$ or $F=\frac{P^1}{2}$ since p^1 equals d

No. 6. $F=\frac{P^1}{4}-\frac{d}{4}$

Hence the principal focal distance is equal in this case to one-fourth the distance between object and image, as previously stated.

If the image shall be in linear dimensions ½ size of object, then $b=\frac{1}{2i}$ and substituting as before $f=\frac{2}{9}\ (P^1+d)$. If $b=\frac{1}{3}i$, $F=\frac{3}{16}\ (P^1+d)$, if $b=\frac{1}{4}$, $F=\frac{4}{15}$ (P^1+d). Or in general if n equal the ratio of object to image, we shall have

No. 7. $F=\frac{n}{(n+1)\ 2}\ (P^1+d)$, but since $n=\frac{d}{P}$,

No. 8. $F=\frac{\frac{d}{P^1}}{\left\{\frac{d}{P}+1\right\}^2}\ (P^1+d)=\frac{d\ P^1}{(d+P^1)^2}$ $(d\ \ P^1)=\frac{d\ P^1}{d\ \ P^1}$. Since P^1 is not separately known this last form is of little use. From No. 7 we see that when d is less with respect to P^1, n becomes correspondingly great, so that little error is made by omitting 1. Hence for distances exceeding 400 feet

No. 9. $F=\frac{P^1\ \ d}{n}$. Results must all be in same units. Correction for F to be deducted in case formula 9 is used.

Value P^1 d, feet.	Multiply F by No.	Value P^1 d, feet.	Multiply F by No.
25	.92	400	.995
50	.96	500	.996
100	.98	600	.9967
150	.98½	700	.9974
200	.99	800	.9975
250	.992	900	.9978
300	.993	1000	.9980

Since P^1 d is the distance from the image shown on the ground glass to the object, and on the ratio of object to image

or the number of times that the image is smaller than the object,—

We have this rule for the focal distance:—*Divide the distance between the ground glass, when the object is in focus, by the ratio of object to image. This will be the approximate focal distance.* Multiply by the number in the above table opposite the required distance, for the accurate focal distance.

REDUCTION OF PHOTOGRAPHS.

For distances used in the practical work of surveying it is seen that the actual focus will not differ sensibly or measurably from the focus for parallel rays. In which case we shall have this proportion, that the focal distance is to the image as the distance to the object is to the size of the object.

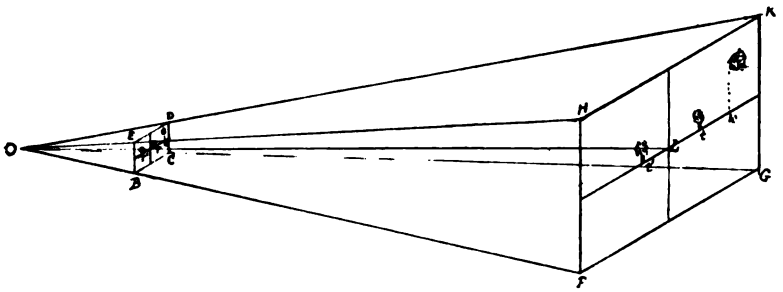


FIG. 7.

Thus in the above figure if *H K F G* is the vertical plane of projection of the actual area to be surveyed and *O* the center of view, then *E B C D* at a distance from *O* equal to *F* is the principal focal distance, the focal distance of the lens will be the picture. Let *O L* be a horizontal line drawn to the center of the field of view, then will *o l* equal *F*. The angle between any two objects as *t* and *t'* would evidently be the same as the angle between the image of the same objects on the picture, with its vertex at *O*. The distance on the horizontal line *T T'* reckoned from the center of the picture either way, is evidently the tangent of the angle, where vertex is at *O* and radius is equal to *F*. If *t t'* is a horizontal line through the vertical plane representing the actual area, the distance $\frac{R\ H}{\text{distance from } O}$ would be the tangent of the angle of elevation.

This is evidently equal to $\frac{r\ h}{F}$ on the picture, so that the angle of elevation can be taken as well from the picture as from the actual landscape.

From this we see that reckoned from the center of a picture on a horizontal line, distances divided by focal length gives us the angle either to the right or left. In the same way angles of elevation or depression can be found by measuring on a vertical line through the object as represented on the picture. If objects are not on these lines, the angles between their projectures on these lines will be the required ones.

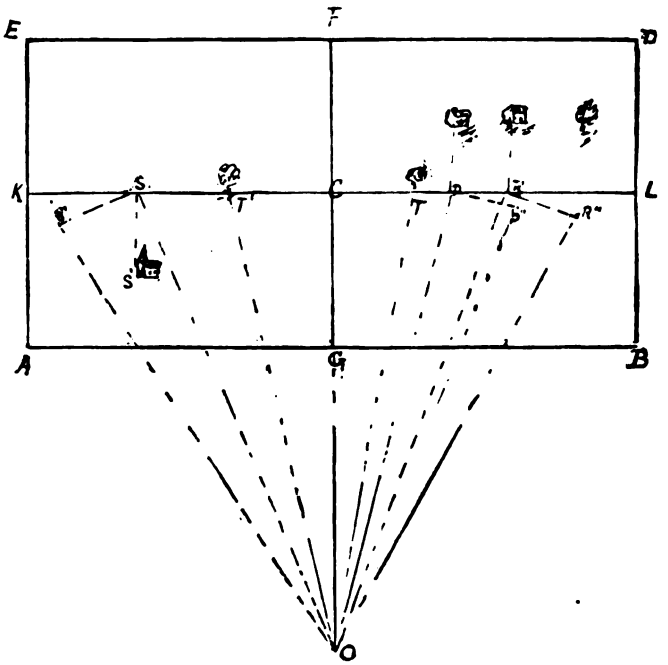


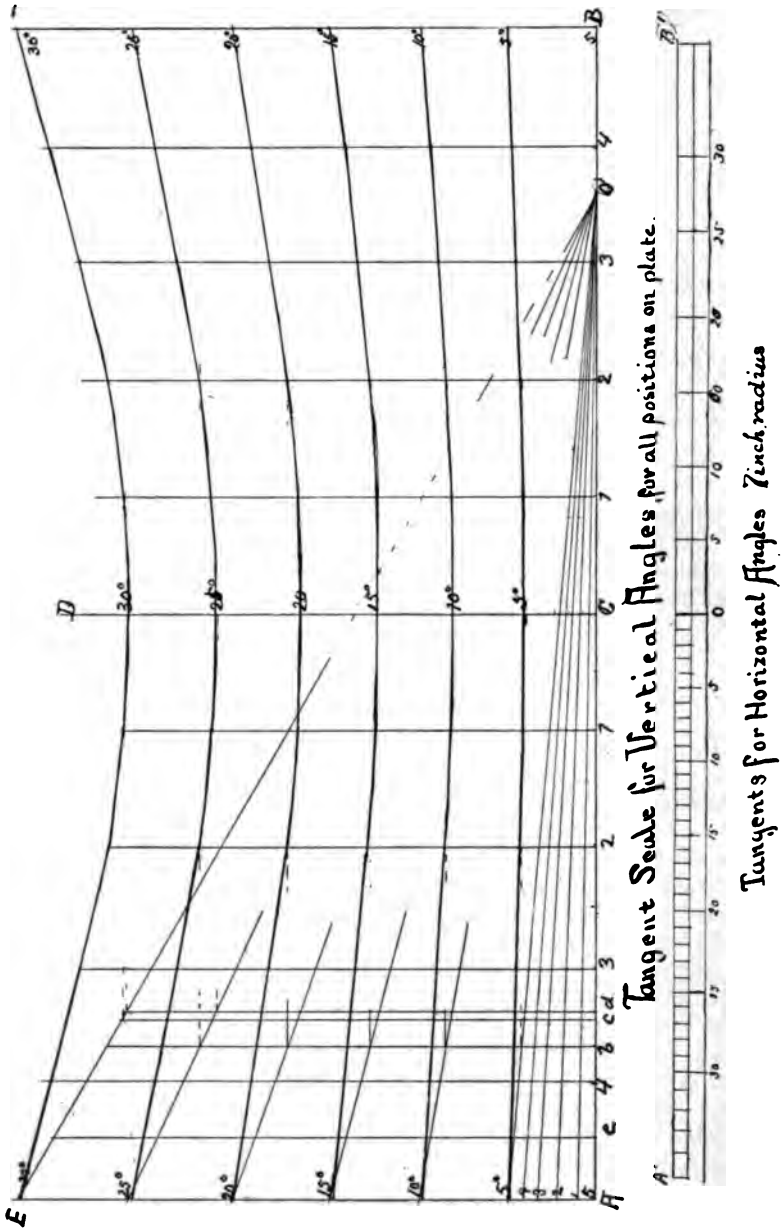
FIG. 8.

The actual process of reducing a photograph is explained by the above diagram, figure 8, which may be supposed to represent some of the prominent objects actually as they occur in the photograph. If the photograph is *A B D E*, the first thing to determine is the position of the horizontal line through the center of the picture. We will in this discussion suppose its position known, and draw this line on the photograph. Next determine the vertical line through the center of the picture, as *F G*. Their intersection at *C* is directly in line with the point of sight. Lay off from *C* in a vertical direction the distance *C o*, equal to the actual focal distance of the

lens; then will o be the horizontal projection of the point of sight. To find the angle between any two objects; first when in the horizontal line $R\ L$, as $T^1\ T$, draw lines from o to these points, then is $T^1\ O\ T$ the required angle. This may be measured with a protracter, or it may be computed, since it is the sum of two angles in the right triangles $C\ O\ T^1$ and $C\ O\ T$, whose tangents are respectively $\frac{T^1\ C}{C\ O}=F$ and $\frac{T\ C}{C\ O}=F$. If the objects are not in the horizontal line $K\ L$, as for instance $R^1\ S^1$, first project by a perpendicular into the horizontal line $K\ L$, R^1 will be projected at R, S^1 will be projected at S. Then is the angle $S\ O\ R$ the required angle which may be measured or computed as before explained. Tangent $S\ O\ C=\frac{S\ C}{F}$. Tangent $C\ O\ R=\frac{C\ R}{F}$. The angle of elevation of the object R^1 may be laid off and measured as follows: Project R^1 to R, draw $R\ O$, from the line $R\ O$ lay off $R\ R$ equal to $R\ R^1$ and in a direction perpendicular to $R\ O$. Draw $O\ R^{11}$ and the angle $R\ O\ R^{11}$ is the required angle. In a similar manner the angle of depression of the object S^1 is found to be $S\ O\ S^{11}$. These angles may be computed, since tangent $R\ O\ R^{11}$ is equal to $\frac{R\ R^{11}}{R\ O}=\frac{R\ R^1}{R\ O}=\frac{R\ R^1}{F^2\ \ T^2\ \ C\ R^2}$.

Also line $S\ O\ S^{11}=\frac{S\ S^1}{F^2\ \ S\ S^2}$.

The work of reduction is thus seen to be comparatively simple. We must know, however, the accurate position of the horizontal plane $K\ L$ and of the principal vertical plane whose trace is $F\ G$. We must also know accurately the focal distance of the lens. The work of reduction may be much simplified by drawing on transparent celluloid a scale of degrees and half degrees for every portion of the picture. This can readily be done since T times $h°$ is equal to the length of n degrees measured on the horizontal or vertical line. Thus from a table of natural tangents multiply each number by the focal distance of the lens area, lay the distances off on the horizontal line from the center of the picture either way, for a scale of degrees. Suppose for instance $F=7$ inches, length of 1 degree on horizontal line equal to $7\times$ten $1°=7\times.01745=.12215$. Length of $2°=7\times.0349=.2443$, etc., up to the number of degrees within the limit of the field.


Tangent Scale for Vertical Angles for all positions on plate.
Tangents for Horizontal Angles 7 inch radius

Lay off these distances from O each way on the horizontal line A^1 B^1. Draw vertical lines through these divisions. This will then be a protractor which can be used for horizontal angles for all the work done with the lens in question, by making the center lines of the protractor agree with the corresponding lines on the photograph. The angles used will give the angular position of the object from the center of view. To make the protractor apply to vertical angles, lay off on the line C D the same diminsions as on the horizontal line. On A E and B F lay off tangents of angles multiplied by the square root of F^2 $\overline{C\ B}^2$, this brings the distance from the point of view to the edge of the picture, G or H.

Repeat the same operations for lines one inch apart between the edges and the center, the multiplier in this case being the square root of the focal distance plus the square of the width of the picture measured from the center. Draw lines through these points, which will be slightly curved, and these will be the measure of corresponding angles of elevation and depression.

To summarize the process, the tangent of any horizontal angle is equal, measured on the center line and from the center of the picture, to the distance on the picture divided by F the principal focal distance. Let a be the distance of the object to the right or left of the center and b be its height above a horizontal line; then tangent of any vertical angle is equal to $\frac{b}{\sqrt{F\ a^2}}$ The method of constructing this protractor for vertical angles is shown in the Figure 8. A B is a horizontal line through the center, C D the corresponding vertical line. Take any point as O^1 from which draw radiating lines any number of degrees apart, in this case 5° apart; these may be drawn by erecting a perpendicular one inch from O' and laying off the natural tangents of the required angles. This protractor being constructed for a lens of 7-inch focal length and for an 8x10 plate, the distance from principal focus to center, equals 7-inch distance, to 1-inch either side of center, and distance equals $\sqrt{50}=7.07$: to a point 2 inches either side $\sqrt{52}=7.28^1$; 3 inches either side $\sqrt{58}=7.69$, 4 inches either side $\sqrt{65}=8$. To a point, from point of view, at 5 inches from center $\sqrt{74}=8.6$. The products of the natural tangents of these various lines can evidently be obtained by drawing

vertical lines across these radiating lines at the required distance from *O'*, thus:—

At distance from *O'*, equal to 7 inches, erect a perpendicular, and where it intersects radiating lines will be the tangents for angles in the center of the plate. This in the figure is the perpendicular from *d*; project these intersections over on the line *C D*, and we have the value on that line of tangents of angles 5°, 10°, 15°, 20°, etc., as measured from the center of the picture. Next erect perpendicular from *C*, a distance 7.07 inches from *O'* and project points of intersection with radiating lines on to perpendicular from I. I, the lines being one inch distance either way from the center of the picture. Do the same for all other distances, draw curves through these various points, and we shall have a protractor for degrees applying to vertical angles above the center. This reversed on the line *A B* would apply below the center.

In using this protractor distances from the center of the photograph can be measured by means of dividers; applying these to the scale above and we shall have the angle from the center of the picture corresponding to the measured distance. Such a protractor worked up on transparent celluloid could be applied directly to the photograph and angles measured without the necessity of using the dividers.

CENTER HORIZONTAL LINE.

The method of finding the center horizontal line of the picture is of utmost importance, as on its position depends all subsequent work with the camera. The method I used was as follows: After carefully leveling the camera, I set up vertical rods by means of the Y level. I found where the horizontal plane of the center of the object glass intersected these rods, and at these points I nailed cross bars that could be plainly seen in the photograph. I marked the position of the image of these cross bars on the ground glass of the camera, turned the lens half way around and repeated the operation. The line found in both ways was coincident. Since that time I have found that a fine thread directly in front of the dry plate holder will be photographed, and I have now arranged two cross wires, one vertical, the other horizontal, that will be photographed in all my subsequent pictures for surveying purposes. With these lines in place and the camera accurately leveled, there will be little chance or opportunity for error, except such as comes from the instrument itself.

MEANS OF LEVELING.

My camera is mounted on a tripod, with leveling screws as used for a Y level. It can be leveled accurately and quickly and will remain where placed. It had a single swing back, but I found it the source of some errors, and, consequently, inserted scews to hold it rigid.

ADJUSTMENTS.

The principal and only adjustment required is that the image of the cross wires, when the instrument is level, shall be in the principal vertical and horizontal planes. The cross wires are best adjusted by an actual trial with objects known to be in the required planes. Once set they will be correct, for the camera is rigid and can not be inverted.

PRINTING PROCESSES.

The negative may be used to measure the angles from by laying the protractor on the glass. It is, however, an inconvenient thing to work from and liable to be broken or scratched. I would recommend some kind of a print.

BLUE PRINTING.

The simplest is the blue print process, and if a first-class special paper, as the Helios, is used, there will be no appreciable shrinkage. This process should be familiar to every one, as it is very convenient to duplicate tracings, and saves in that way untold labor. The chemicals used are—

Red prussiate potash, 1 part,
Citrate of iron and ammonia, $1\frac{1}{4}$ to $1\frac{3}{4}$ parts,
Water, 6 to 8 parts.

These chemicals should be dissolved separately and kept separate until needed. They can then be mixed and applied to the paper with a brush or a sponge. For printing from negatives a better solution will be had by using only about half as much water as given above. The chemicals can be applied by lamp light and the paper dried during the night; it must not be exposed to the light when dry. The writer discovered a queer property of blue print paper,—that if exposed to the light when wet it will turn light instead of dark. It will keep, however, a long time in a dry dark place. Any good linen paper can be used, but the best results are obtained on special paper made for this purpose.

For the purpose of printing, a frame, or some device, is necessary to hold the tracing or negative in close contact with

the sensitive paper. For the use of negatives, printing frames can be bought cheaply, and these would form a good pattern for larger frames for tracings.

Prof. Cleaves, of Cornell University, obtains excellent prints by clamping the sensitive paper and the tracing outside to a thin board. This board by means of a lever is sprung into a convex form with the tracing exposed. This makes a good contact and forms a cheap frame.

SILVER PRINTING PROCESS.

This is very complicated, and details can be had of any photographer; it is in fact the most difficult process in the art of photography. Albumen paper, which is ordinarily used, will shrink some and probably unequally; so it can not be recommended for this purpose. Aristotype paper is better in this respect, but so far as my experience goes, it runs very uneven and results are very uncertain. Arrowroot paper can be made nearly as readily as blue print paper, especially if one possesses a silver bath. It prints very quickly, gives detail without gloss, and is a rich dark brown, even if not toned. I have had good success with this paper, and give the method of preparing.

The formula I have tried is as follows:—

3½ parts arrowroot,
2 parts common salt,
100 parts of water.

The arrowroot is first dampened with water and mixed to break up lumps, then add remaining portion of water in a boiling condition. Dissolve the salt at any time.

To sensitize this, float on a silver bath, not to exceed 1½ minutes; a longer time will make the print gray. Fume with strong ammonia for 8 minntes, directly before printing; this will have the effect of making the prints bright, and darker.

Prints are made from this paper as from blue prints; it requires about 8 minutes exposure. They are then washed, toned and fixed as silver prints. The fixing bath consists of six parts of water and one part of hyposulphite of soda.

I feel that I have as fully described the process as the limits of this paper will permit, and with a few practical suggestions I will close. First, in regard to the size of camera. I purchased an 8x10 size, and I have found except for a few cases that a smaller size, for instance 5x8, would answer equally well. A plate 8 inches across is not much smaller than one 10 inches. Second, in regard to the kind of lens. I am fully satisfied that for this purpose, a lens of the wide

angled variety, rather than of the rapid rectilinear, is to be selected. You will need an excellent lens, aplanatic, one that is free from aberration, and the focal length ought to be nearly equal to the longest dimension of the plate. That is for a 5x8 plate use a lens with 8-inch focal distance; with an 8x10 plate use a lens with 10-inch focal distance. In either case the tangent of one-half the extreme angle covered by your plate will be .5, and the resulting angle = 54° nearly. So that in such a case the smaller plate covers the same field as the larger one, but the picture is to a smaller scale. The difference is in favor of the smaller plate for most work, because the instrument is more portable, more readily handled, and much cheaper in first cost.

In the wide angle type of cameras the diaphragms are of the rotating type and are fastened in the lens; consequently they are always in place and can never be lost.

A lens that covers 54° as an extreme angle will do accurate work probably over 45°, so that 8 views would be necessary to complete the horizon or to make a complete circuit of 360°. Usually two views will be all that is required at a station, as angles that on measure seldom exceed 90°.

The cost of a 5x8 photo-surveying outfit will be about as follows:—

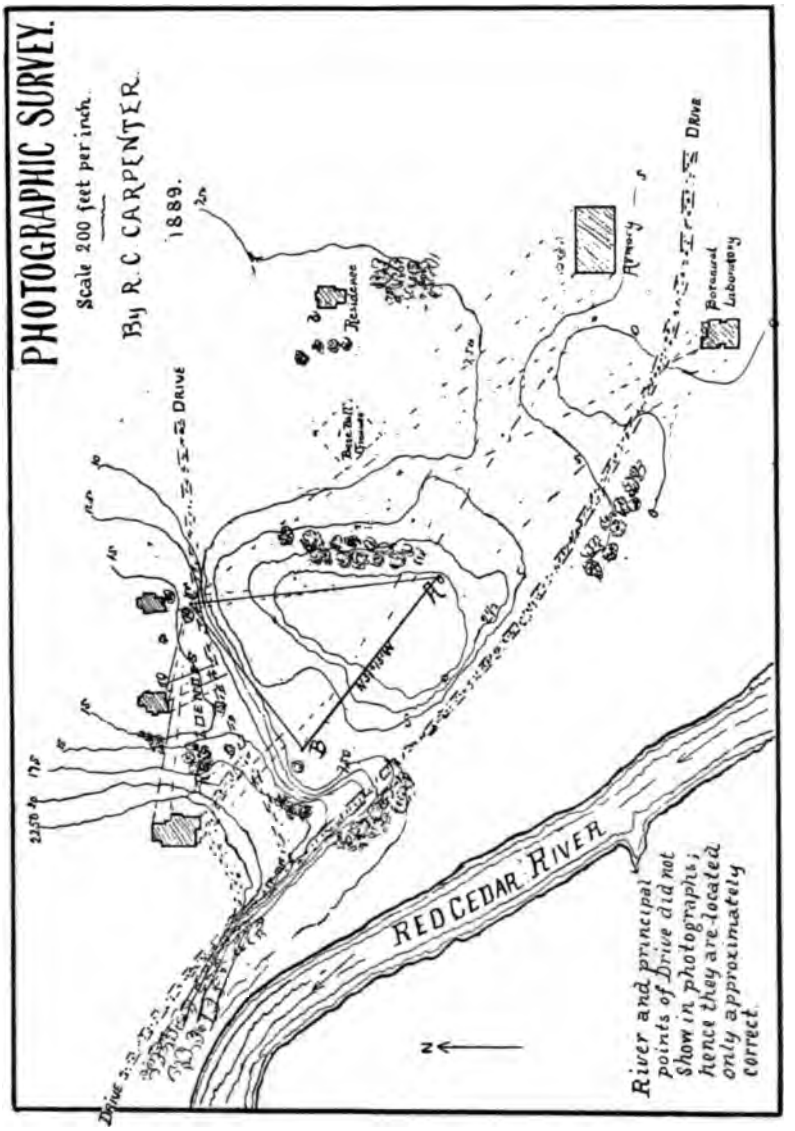
Lens,	$20.00	to	$40.00
Camera (no swing back),	5.00	to	15.00
6 Double Plate Holders,	9.00	to	12.00
2 Printing Frames,	1.00	to	1.00
Developing Trays,	1.00	to	1.00
Total,	$36.00	to	$69.00

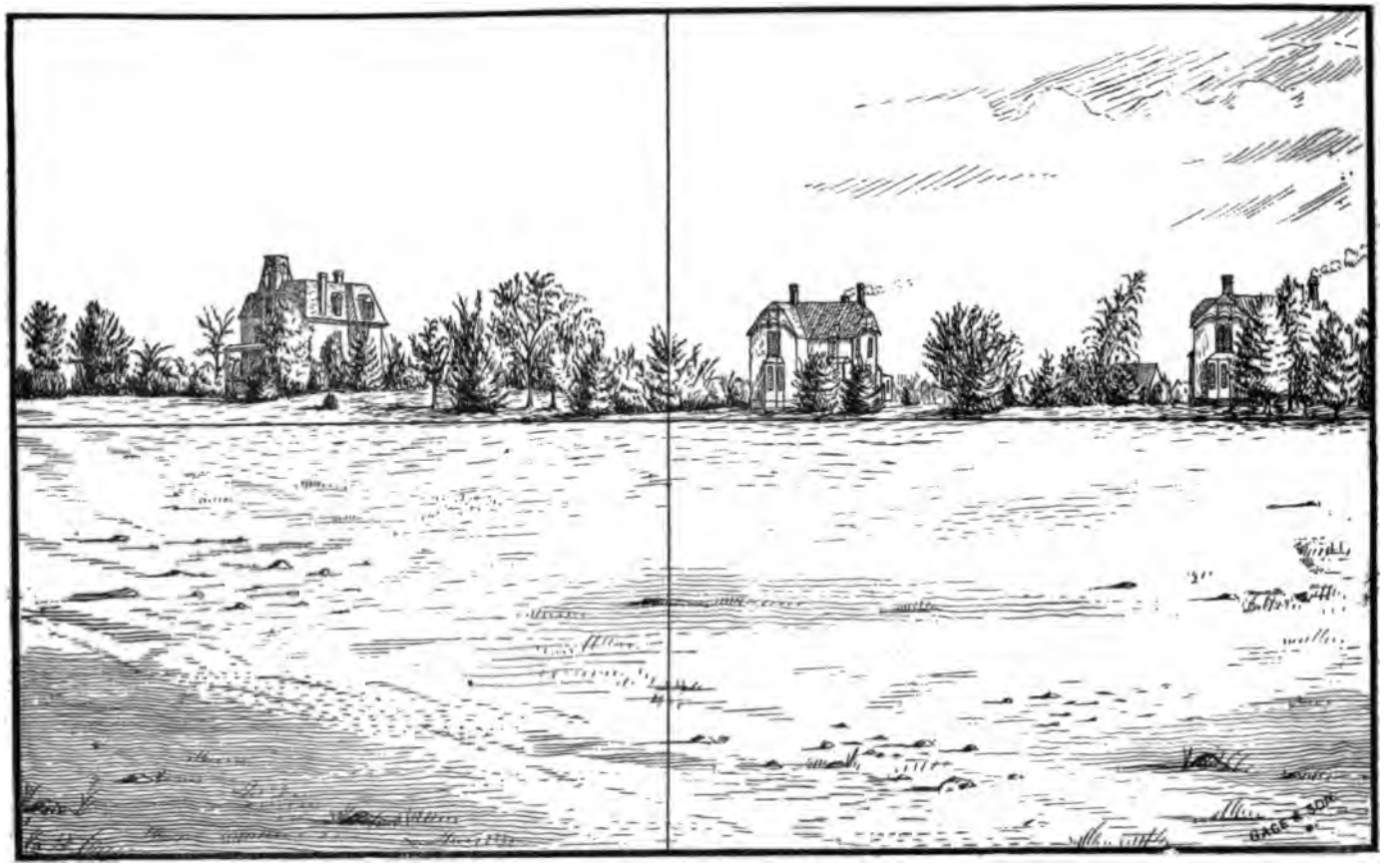
The above does not include a special tripod such as would be needed for surveying, nor does it include apparatus for silver printing. Sensitive dry plates 5x8 cost $1.25 per dozen.

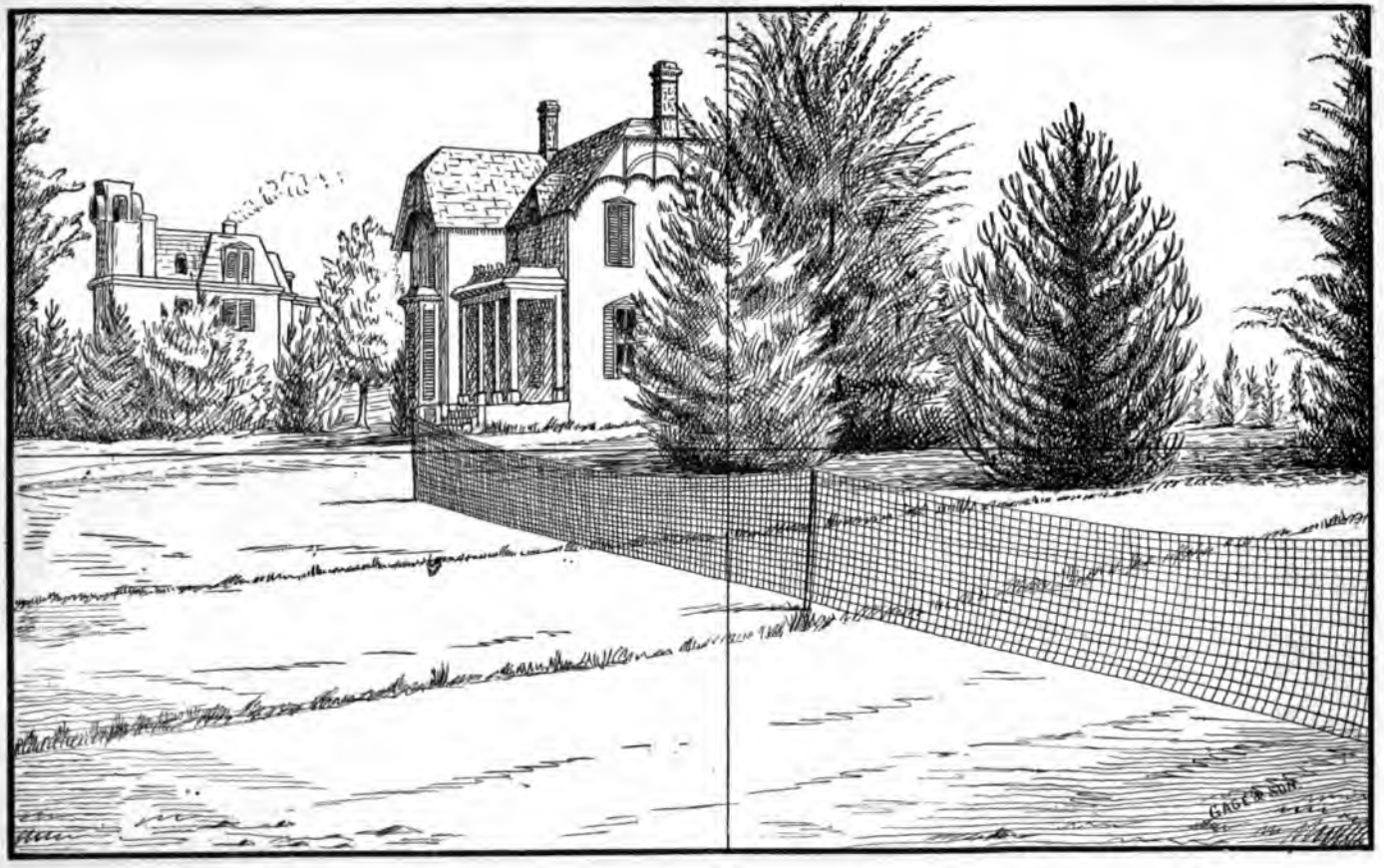
The cost of an 8x10 outfit, suitable for photo-surveying, will be as follows:—

Camera,	$ 8.00	to	$25.00
Lens,	30.00	to	50.00
6 Double Plate Holders,	10.00	to	12-00
2 Printing Frames,	2.00	to	2.00
Developing Trays,	2.00	to	2.00
Total,	$52.00	to	$91.00

This does not include tripod, nor silver-printing outfit. Sensitive dry plates 8x10 cost $2.40 per dozen.


PHOTOGRAPHIC SURVEY.
Scale 200 feet per inch.
By R. C CARPENTER.
1889.
REDCEDAR RIVER
Residence
Boiler House
Laboratory
River and principal points of Drive did not show in photographs; hence they are located only approximately correct.


GAGE & SON


GAGE & SON

The map which is presented with the article was worked up as follows:—

The distance from *A* to *B* was accurately measured with a steel tape and its bearing taken with a compass. The camera was then located at *A*, a station was established at *C*, and a photograph taken which includes both *B* and *C*. The camera was then moved to *B*, the other extremity of the base line. In order to include both *A* and *C* it was necessary to take two views, one view including station *A*, and the residence shown to the east side of the map, the second view, showing the same residence and station *C*. The instrument was then moved to *C*, and three views taken, one to the west, one to the north-west and one to the south-east. From the intersection of lines taken from these various photographs the accompanying map was drawn.

The writer regrets very much that time did not permit the production of a much more elaborate map. It will, I think, show the possibilities of photographic surveying. Two of the six photographs from which the map was constructed are reproduced; viz., the view from *A* including both *B* and *C*, and the view from *C* westward, showing intersecting lines.

R. C. CARPENTER.

In connection with Prof. Carpenter's paper, Mr. C. A. Stacey made an exhibit of the photographic stock manufactured and sold by the Eastman Company, of Rochester, N. Y., and demonstrated the manner of use. Mr. Stacey showed the workings of the Eastman system of film photography, by making a negative of the members in a group on a $6\frac{1}{2}$x$8\frac{1}{2}$ transparent film, which was developed on the spot. The developer formula used was as follows:—

No. 1.—*Pyrogallic Acid Solution.*—Pyrogallic acid, $\frac{1}{4}$ ounce nitrous or sulphuric acid, 10 minims; water, 16 ounces.

No. 2.—*Soda Solution.*—Sulphite soda (crystals), 3 ounces; carbonate soda (crystals), 2 ounces; water, 16 ounces.

To develop, take No. 1, 1 ounce; No. 2, 1 ounce; water, 2 ounces.

Fixing Solution.—Hyposulphite soda, 4 ounces; water, 16 ounces.

Mr. Stacey made several demonstrations with flash light and the "quick" bromide printing paper.

The Kodaks were placed in position (several sizes being used) and groups made by use of the flash light. The plates

or transparent film were cut from the roll holder and developed, and passed around among the audience.

The No. 4 Kodak, for 4x5 square pictures, has two finders, one for vertical and one for horizontal pictures, and a fine lens, made by Bausch & Lomb. This Kodak has an instantaneous shutter, which can be set for time exposures; also having rotating stops and adjustable shutter tension, two sockets for tripod screws, rack and pinion for focusing, and when it is loaded, weighing only four and one-half pounds.

The No. 3, for $3\frac{1}{4}$x$4\frac{1}{4}$ pictures, when loaded, weighs four pounds.

At the last evening session, printing and developing the "quick" printing bromide paper was done, making prints from the film negatives of the members which were made at other sessions, so that all could see the workings complete. The printing was done by electric light, also by daylight in a few seconds exposure.

We give below the formula for working the bromide paper.

The requisites for working bromide copying paper for copying drawings or plans, or making photographic copies of any suitable objects, are as follows:—

1 printing frame, of the required size, with glass.
1 glass graduate.
1 minim glass.
2 japanned trays.
1 pound oxalate potash.
1 pound proto-sulphate of iron.
1 pound hyposulphite of soda.
1 ounce bromide potassium.
$\frac{1}{4}$ pound citric acid.

Suitable bottles for contaning the solutions, and a supply of yellow post office paper.

DIRECTIONS.

No. 1.—Dissolve the $\frac{1}{4}$ pound citric acid in 1 quart cold water.

No. 2.—Dissolve the 1 pound oxalate potash in 3 pints hot water.

No. 3.—Dissolve the 1 pound proto-sulphate iron in 1 quart hot water.

No. 4.—Dissolve the 1 pound hyposulphite soda in 5 pints cold water.

No. 5.—Dissolve the 1 ounce bromide potash in 1 quart cold water.

Add to the oxalate of potash solution two ounces of the citric acid solution, and to the iron solution one ounce of the citric acid solution.

All the above solutions keep indefinitely.

Light for Operating.—Bromide copying paper is very sensitive to all white light, whether natural or artificial, and it is owing to this fact that it can be used for making photographic copies of any kind in a few seconds, by either daylight or lamplight.

To prevent the premature action of the light, it must be manipulated only in yellow or red light, to which it is practically insensitive.

To obtain such a light all that is necessary is to fit into the window of the operating room a cloth screen covered with yellow post office paper, or if the operations are to be conducted at night, a truncated cone formed of the same paper and placed over a lamp on the table will give the proper quality of light to operate by. The opening in the top of the cone should be just large enough to permit the heat to escape without scorching the paper.

To Make the Exposure.—We will suppose that the operator wishes to make a copy of a drawing or tracing, and that he is working by lamplight. Proceed as follows: Lay the drawing, face up, on the glass in the printing frame, and after putting the yellow cone over the light, open a package of the bromide copying paper and take out one sheet; lay it face down upon the drawing in the frame, fasten in the back and stand the frame in front of, and say fifteen inches away from the light, so it will fall evenly upon the glass, then raise the yellow paper cone and let the white light shine directly upon the drawing behind the glass. The proper time of the exposure depends upon the intensity of the light, the opacity of the drawing and the distance between the light and the printing frame. Working under the same general conditions, the operator will soon learn to judge accurately of the time required, but in the first instance it will have to be determined by experiment. The quickest way to arrive at the desired point is to partially cover the frame with a piece of card-board and make the exposure in sections, each one having a different period of time.

If the light is from an ordinary No. 2 kerosene burner and the drawing is on white bristol-board, with a distance of fifteen inches between the light and the printing frame, the exposure would be, say two minutes. For a trial give the first section exposed one minute, then draw the card to expose still more

of the drawing, and give one minute more, draw it still further and give another minute, and finally remove the card and give still another minute. The drawing will thus have been exposed in four sections, having respectively four, three, two and one minute exposures.

Replace the paper cone over the lamp, and taking the sheet of bromide copying paper from the frame, lay it in a tray and cover it with clean, cold water; while it is soaking prepare the developer.

The image formed by the light is invisible on the paper when taken from the frame, and has to be brought out by chemicals, called the developer.

THE DEVELOPER.

Take of the solutions prepared as before described, as follows:—

No. 2, oxalate potash solution, - -	3 ounces.
No. 3, proto-sulphate of iron solution, -	½ ounce.
No. 4, bromide potassium solution, -	1 dram.

Mix in the order given, and after pouring off the water from the paper in the tray, pour on the above. In about half a minute the paper will begin to turn dark where the light struck through the drawing paper, leaving the portions protected by the black lines white, thus producing white lines upon a black ground. When the exposure has been correct the lines will be pure white and the ground pure black. The developer should be allowed to act until the parts acted upon by the light are a deep black, then pour off the developer, and pour on, say one ounce of the citric acid solution. After allowing it to act a minute rinse the paper two or three times in pure water and then transfer it to a second tray in which there is sufficient of the hypo-sulphite of soda solution to cover it well; this is called the *fixing solution*, and it removes all the silver not blackened by the developer. After allowing it to act about five minutes return it to the first tray and wash it well for ten or fifteen minutes in running water, then pin it up to dry.

The Drawing.—To produce a good copy the *lines* of the drawing must be *strong and black*, so that when held up to the light no rays will pass through them. If the lines are black a good copy can be obtained from any drawing, whether on the thinnest tracing paper or the heaviest manilla. The only difference being the time required to print.

Uniform Illumination.—When printing by artificial light the distance between the frame and the light should be at least equal to the length of the frame to insure an even illumination.

To Make Non-reversed Copies, the *back* of the bromide copying paper should be laid against the face of the drawing. When making exposure for non-reversed copies hold the frame as far as convenient from the light to get the rays as near parallel as possible; this will increase the time of exposure as the square of the distance. Allowance should also be made for the fact that the light must pass through both the drawing and the bromide copying paper. For instance, say we have to copy a patent-office drawing on heavy white bristol-board. The time of exposure, if the drawing and bromide copying paper are face to face (making a reversed copy), will be about two minutes, fifteen inches from a No. 2 kerosene burner. If the back of the paper is laid against the drawing, the exposure at same distance will be one-half greater, viz: three minutes, while if the distance is increased to two feet to get a sharper image, the time will be eight minutes.

Daylight.—If the exposure is made by daylight the time will be much less, not more than one-fifth to one-twentieth, if made in front of an open window. In exposing by daylight care should be taken to avoid over exposure, by using a piece of straw board so as to cover and uncover the frame quickly.

Negatives and Positives.—A contact print from a drawing will be a negative, that is, the lines will be white and the ground black; if the negative is used to make a second print it will produce a positive or *fac simile* of the original. It is not necessary to dry the negative before making the positive. The piece of bromide copying paper for the positive should be soaked in water and laid, back down, upon a piece of glass or hard rubber, then lay upon it, face down, the wet negative and press them firmly into contact with a rubber squeegee, expose, separate and finally develop the positive as above directed. Negatives should have full exposure and long development to get as much density as possible, so that the positive will show a pure white ground with black lines.

Bromide Copying Paper may be used for copying plans, drawings, letters, documents, or printed matter of any kind by contact, when the matter to be copied is on one side only of the original. It can be used for making copies of leaves, dried or undried, for botanists' use. It can be furnished in rolls of any length or width for recording instruments in astronomical observations, etc., and it is available for many

other purposes where a sensitive paper that will keep both before and after exposure is desirable.

Hypo. Stains.—The hyposulphite of soda solution, if allowed to mix with any of the other solutions, will cause irregular black markings. The hands must be well rinsed after using it, to avoid stains on the paper.

Blisters sometimes appear in bromide paper, and may be avoided by using a little common salt in the first water after fixing. Dissolve two tablespoonfuls common salt in one pint water ; put the print into this as soon as it comes out of the fixing solution ; allow it to act one minute, then wash and dry.

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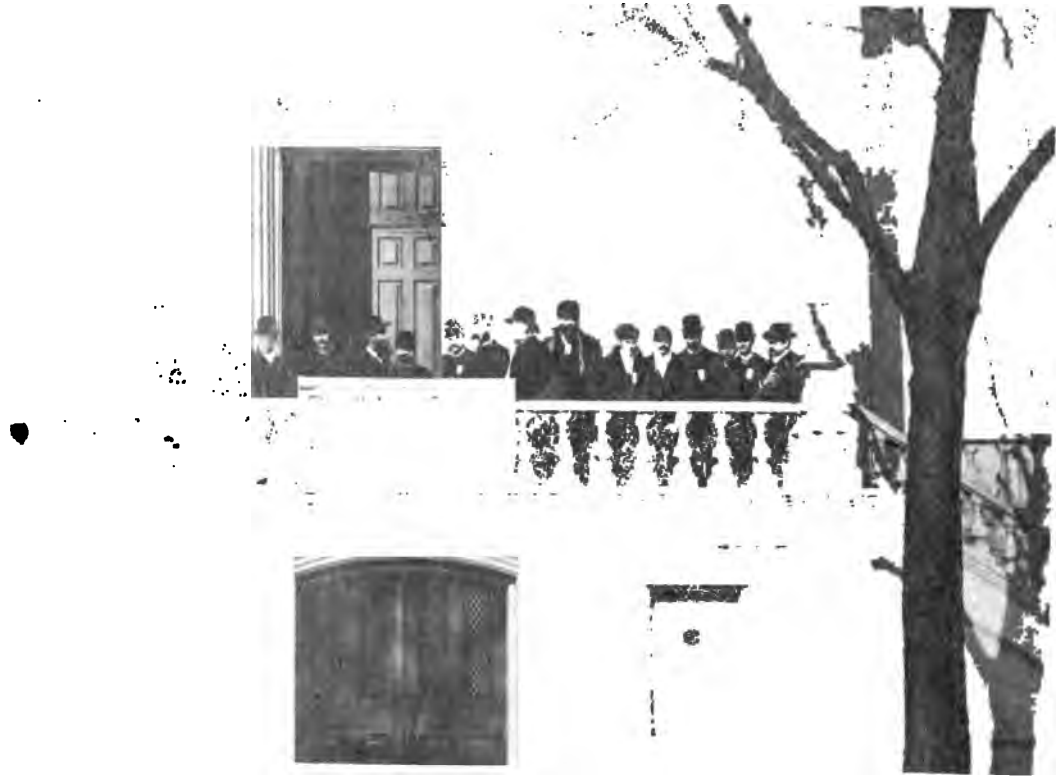

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THE PLANE TABLE.

THIS is a surveying instrument in use for obtaining the very last details, and for topographical work. It is not very accurate, but will give uniform results, so that if the scale is small, or the results are not needed with too much accuracy, it answers a very good purpose. Years ago it was in use on the U. S. Lake Survey, but was abandoned and a transit and drawing board taken into the field in its stead, I believe. This was because the men on the survey were not pleased with the trustworthiness of the results obtained. As you are aware, this instrument consists of a drawing board mounted on suitable devices for putting and keeping it level. On this board is stretched a piece of paper, and a map of the work is carried forward as the work progresses. In connection with the plane table there is always used an alidade. This alidade is nothing but a rule or straight edge, and a line of sight. The line of sight may be the edge of the rule, or be defined by a pair of compass sights or a telescope. All that is necessary concerning this line of sight is that it should range in a plane perpendicular to the under side of the rule. In order to make the adjustment easy it is customary to make this line of sight range, or revolve, in a plane parallel to the edge of the rule, as well as perpendicular to its under side. It seems as though the plane table would solve some problems not possible with the transit, because of the map being combined with the instrument, but such is not the case. One of the more notorious of these problems is the Two-Point Problem of the books. This can be solved by the transit as well as with the plane table.

I shall be more particular to mention those things not to be found in books. By the books one is instructed to set the plat of a point on the table over the point on the ground which it represents. There is provided and sold a sort of a U for the purpose of plumbing down from the point on the table to the point on the ground. But with the aid of all the devices to be obtained it will be a mere chance if when the table is set the point on it is over the point on the ground which it represents. The reason of this is that the table must be set always parallel to its first position on the survey, and so it occurs that when it is set so the point on it is over the point on the ground which it represents, the first thing to be done is to turn it slightly from this position in order to orient the table, that is, set it parallel to its first position, and so destroy the relation of the two points which was so carefully obtained. This is to be considered a vital defect in the use of the plane

table and no doubt it has led to the abandonment of its use in numerous instances. This defect I remedied some fifteen years ago or more by setting the table central over the point of observation with a plumb bob just as a transit is set. I find by reference to my class records that I was giving instruction in this manner of using the plane table in 1875. There are required for use with the plane table when operated in this manner two triangles. These are carried instead of the U-shaped tool before named. The plumb bob is hung at the center of the instrument as in any case. It is also necessary to find the center of the sheet of paper on the drawing board, that is where the spindle axis of the board will pierce the paper. This may be very easily done for each sheet of paper but a much better way is to do as follows: Fix some sharp pointed tool, like a knife or a needle point rigidly, so it will barely scratch a fine mark on the face of the board when it is turned on its spindle under this fixed point. By these means scratch the circumference of a circle, or parts of one, on the face of the board. Make sure it is nicely and precisely done. Construct the center of this circle. It will be the center of the board as above described. Set in a piece of brass flush with the face of the board so that a hole in it of a suitable size to admit a common pin will mark the center permanently. Whenever a new paper is put on the board a little search will enable a pin to be pushed through the paper into the hole in the brass where it should fit and be left standing for convenience in using the board. By this arrangement the alidade, which, as usually constructed, is of considerable weight, will always stand central on the board and not near its edge. This will give increased steadiness and stability. To illustrate the manner of using the plane table in this case I will describe a few of the operations necessary to start a survey, well knowing that when that is done the work can be followed out readily. Take the plane table to the first point of the survey or to the place where it is to begin. Set it over the point just as a transit would be set with the plumb bob from its center and over the point. Observe to set the table so low that the edge of it will come at the bend of the body just below the hips of the person who uses it. This is necessary to make the working of the table convenient and to prevent liability of resting the weight of the arms or some part of the body on the table, which must not be done. All beginners are apt to set the table far too high. Next clamp the spindle of the table so it will stand in a position suitable for receiving the work to go on it with reference to the point it stands at, remembering that

always after this it must be set parallel to this, its first position. Place the alidade central on the table with its level tubes parallel to the pairs of leveling screws below. Carefully level the table. It is now ready for use. To begin observations to other points of the work, first choose which hand the rule of the alidade is to be used on, that is make a choice of which side of the lines observed along, with references to the observer, either to his right or to his left, the rule shall be set. Having made this choice it must be continued throughout the work, to avoid introducing the errors of some of the adjustments into the work. It is well for a right-handed person to use the rule on his left of the lines and on the right for a left-handed person. This must be continued to be done when looking along any line in either direction. Having made this choice, place the work edge of the rule of the alidade gently against the pin in the centre of the sheet, and with the hands, sliding the alidade on the paper but always keeping it up to the pin as noted, bring the line of sight on to the line to be observed and leave it carefully set there. Choose the place on the paper where the plat of the first point of the survey shall be and prick it down with a needle point or note it precisely in some way. Place one of the triangles against the rule and the other triangle against the first named so the first named can be slid over the paper and have its edge that was placed against the rule pass through the chosen point. Make the transfer of the line from the rule to the point and draw the line on the paper through the point. Slide the triangle back to the rule and make sure there are no slips. See if the line of sight still stands on the line it was set on. If these checks show errors, review the operations and correct them. These operations can be repeated for any number of points or lines. Finally before taking the plane table to a new place, try the position of the table by the first line laid down on it. To do this, set a triangle to this first line as it is drawn on the paper and slide it over to the center of the sheet. Grasp the alidade firmly and set it by the edge of the triangle at the center of the sheet so it—the rule—will still stand parallel to the line. See if the line of sight strikes the first line of observation. It may not fit with great precision,—this is not to be expected,—but a little experience will show when it will be necessary to review the work. By these means make sure of the stability of the table during the observations. Having done this the table may be carried to the next point of the survey and set up and leveled as before, except now there will be no use in trying to set it by estimation in position

only in a general way. After it is leveled, slide the line from the plat of the point at which the table stands to the plat of the point from which it came, over to the center of the sheet and set the alidade by it as before described for testing the stability of the table at the last point. Be sure to keep the rule on the *same hand of the observer, not* on the same side of the line. Having set the alidade as above noted, slide the triangle back to the line and see there are no slips. By means of the clamp and slow-motion screw to the spindle, set the line of sight on the point from which the table came. Now, the table is said to be oriented, that is, it stands parallel to its first position. Observations may now be made as at first. They may be continued at will, but observe to test the stability of the table, and the quality or correctness of the work and the various observations connected with it so frequently that the result obtained may always be received with confidence that they are as good as the plane table will give.

For the methods of determining the positions of points, and the various plans of conducting a survey, the text books on surveying may be consulted. For this purpose see Gillespie, new edition. Johnson gives a little about the plane table, but there is a more complete work entitled The Plane Table, from the papers of the U. S. Coast Survey. No trouble will be found in adapting the processes given in these books to the method of setting the center of the board over the point of observation in the regular way of using other instruments, and better results will be got with greater ease, comfort and speed.

With the plane table goes its plumb bob, the alidade, the triangles, a scale, three-legged dividers for transferring points, hard pencils, erasers, pocket knife, thumb-tacks in plenty, a little compass box made for this especial service (sometimes this is on the rule, but better be separate), and a large piece of rubber sheeting or light rubber cloth of a size to envelop the table and all there is on it, and tack under the board, to secure the drawing and the various things from the rain or dust as occasion may require. There may be a place made under the board to keep the triangles, the scale and some of these things in.

The telescope on the alidade may have a vertical circle, a level on the telescope tube, and be fitted with stadia cross wires. These devices are all well described in books, and will be found of service in much plane table work. The stadia may be used for measuring heights and distances roughly for topography. The distances in good stadia work compare well

in precision with the common chaining before the day of the steel tape. Hence it is quite good enough for topography. I mention these things to call attention to the fact that the stadia will measure a designated distance, and, with the vertical circle, a designated height and distance, but that it cannot be used to set out, lay off, or measure, a given height or distance,—as 745.14 feet. It solves but half the problem. This is the simple—and sufficient—reason why it has never come into more general use. No one should attempt to lay out work with a stadia, unless ready to part with his eyes, as all experiences of this kind, within my knowledge, show that this will be the result very shortly. The stadia is so frequently used with the plane table that I deem this word of caution necessary.

The determination of the sides and angles of a triangle with a plane table presents all the difficulties or peculiarities of plane table work, except in one case, that of determining a fourth point from three others, known as the three point problem. What appear in the books to be more than this really are not. The three-point problem having been much discussed and elaborated, especially in former times, I will suggest still another solution of it that will be found convenient for use on the plane table. This solution is entirely mechanical and requires no rules, or equations, or geometry. This is the three-point problem: Knowing the location of three points, that is they are platted down on the plane table, the position of a fourth point may be determined by setting an instrument at this fourth point and observing the angles between lines from it to the three given points. To do this, set the plane table at the fourth point, without attempting to orient it, dampen it, and draw three lines by the rule from the center of the sheet running to the three given points. An extra piece of paper may be put on over the sheet if desired for this purpose. Fit the three-legged dividers with one foot on the plat of each one of the three given points. Notice which way from the three given points on the ground the fourth point, at which the table stands, is. Fit the three-legged dividers, carefully set as above noted, on to the three lines drawn toward the three points from the center of the sheet, so the center of the sheet, which represents the fourth point, will be in its relative position with respect to the three feet of the dividers. Make the adjustment with precision. Now prick down the three points on the three lines, and these, with the center of the sheet, will show the relative position of the four points on the ground to the scale used. Set the

three-legged dividers on two of these and the center of the sheet. Place the two feet on the plats of these two points on the map and prick down the plat of the fourth point with the third leg. It may, of course, happen that the plats of the three given points cannot be spanned with the three-legged dividers. This is easily met by reducing the distance between them by the same ratio, and thus obtaining three points the dividers will span. Then solve the problem with these three, and the resulting four point figure will be too small by just the ratio of reduction used.

For all such work a pair of three-legged dividers of considerable size is needed, having the third leg sliding in a sleeve with a clamp, so it can be set at any length within the limits of the piece.

I solved the problem in this way at about the time mentioned above as the time when I began working from the center of the sheet. There are six possible solutions. Three of these are easily traced out by trying the experiment. The other three might be missed, and are to be found by turning over the paper on which the three lines are drawn, and applying the dividers to the back side of the paper. I also tested the solution in the special cases, and when the four points are on the circumference of a circle. I examined all these results to see if there was anything in them likely to confuse the operator. There was not. Be sure to notice which way from the three given points the fourth one is, and apply the dividers to the three lines accordingly. That is all.

The ordinary problems in surveying I solved many years ago with the plane table. Some of these are laying out circular curves, parabolic curves, finding the azimuth of a line astronomically, and the like. But these things are of the nature of curiosities or extreme exceptions, and are much better done with other instruments.

In taking charge of any instrument for the first time, look over even the simplest matters, and see that everything is in order from the ground up. From that on, these matters constitute a part of the operator's general care. This is especially true of the plane table. See that the shoes at the bottoms of the tripod legs are tight, and do not rattle. See that the legs work tight enough at the cap. See to the tripod head and its connection with the board. See that the arms under the board are tight fast to it; that the board itself is flat and square to the spindle. See that the rule is straight, and the two edges of it parallel, so one may slide off lines from either edge.

Plane tables are sold from $150 to $350. The great point to be considered is steadiness of the table. I have never been informed why these instruments are charged for at the rate they are. The prices seem very high to me. The board should be of dry, soft, even, straight grained pine. The same defects of construction attend these instruments that do others. The clamp on the vertical circle is bad, and many other similar defects are to be found.

I will conclude by giving, in a compact form, the adjustments of the plane table.

1. See that the edge of the rule is straight by testing it on a fine pencil line, and correct it if need be. Also see that the two edges of the rule are parallel by drawing fine lines by each edge, and testing them with the dividers.

2. See that the surface of the board is a plane, by testing it in all directions with a straight edge, and working it down, if need be, with a smooth plane, a scraper, or sand paper.

3. Levels on the rule.

Set up the board and level it.

Draw a line by the edge of the rule, and mark the place of the ends of the rule.

Remove the alidade and replace it on the board on the opposite side of the line, just fitted to it, and the ends of the rule at their marks.

See if the bubbles show level.

If not, reverse the alidade back again and make a few reversions till satisfied the bubble tubes are out of adjustment.

Leave the alidade so as to show the error.

Correct one-half the apparent error by means of the screws that hold the tubes to the rule.

Test the adjustment as at first.

Repeat the tests, corrections and tests till no error appears.

4. Board square to spindle.

Set the plane table and level it with the alidade central.

Reverse the table on its spindle.

See if the bubbles still read level.

If not, reverse back, and by repeated reversions make sure if any error exists.

Leave the table so as to show the error.

Correct one-half the apparent error by inserting wedges between the arms and the board, beneath it.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

Having the board thus properly set, replace the wedges by suitable washers or other devices of a permanent and durable kind, and finally fit these so that the above described test shows no error.

5. Line of sight at right angles to telescope axis.

Set up the table and level it with the alidade central.

Find two points in apparent line and clamp the spindle with the line of sight set on them.

Reverse the telescope carefully on its axis and find a point in apparent line in the opposite direction.

Reverse back again, and by repeated reversions make sure the table and alidade are steady.

Lift up the alidade, change ends with it, and replace it on the table in a reversed position with great care. Set the line of sight on the two first named points, for which purpose the spindle slow-motion screw may be used, if need be.

Reverse the telescope on its axis and see if the third point is in line.

Reverse back again, and by repeated reversions make sure the table and alidade is steady.

Leave the telescope looking at the third point, so as to show the deviation of the line of sight therefrom—or the error.

Correct one-fourth this apparent error by moving the cross-wires by means of the screws that hold them in the telescope tube.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

The above directions apply to a telescope that can be reversed. In case it cannot be reversed, the wyes must open and then the line of sight adjustment be made by pointing on any point; lifting the telescope out of the wyes; turning it over; replacing in wyes, same end towards point; seeing if line of sight now strikes the point; correcting one-half the apparent error by the cross-wire screws, and testing, and correcting and testing till no error appears.

6. Adjusting telescope axis vertically.

This makes the line of sight revolve in a plane, perpendicular to the under side of the rule.

Set up the table as near some high, well-defined, fixed point as it can be, and that point be observed through the telescope with the alidade central on the board. Place the alidade central on the table, and level it carefully.

Set the line of sight on the high, fixed point, by means of the spindle clamp and slow-motion screw.

Turn the objective downwards, till the line of sight points at nearly the same angle below the horizon that it did above. Find or take two points near by in apparent line, ten or fifteen feet apart, with little or no change vertically in the pointing of the telescope.

Make sure of the stability of the telescope, by repeated pointings upon the upper and lower points.

Reverse the alidade and the telescope on its axis. Set the line of sight so as to range upon both lower points, using the spindle clamp and slow-motion screw.

See if the upper point is in apparent line. Repeat the pointings, to make sure of the stability of the telescope. Leave it looking at the upper point, so as to show the error.

Correct one-fourth the apparent error, by means of the device provided for controlling the inclination of the telescope axis to the horizon.

Test the adjustment as at first.

Repeat the tests, corrections and tests, till no error appears.

7. Adjusting the telescope axis, horizontally.

This makes the line of sight revolve in a plane parallel to the edge of the rule.

Provide a firm, level support for the alidade. Two stout, square-topped stakes properly driven may answer. This support may be leveled by the alidade. The cross level is the more important, but both should be level. From this support the line of sight should strike a distant, well-defined, fixed point. Have ready a needle, needle point, or a similar tool. Put a paper on the table.

Set up the table about 20 feet from the alidade support and on line from it to the distant point. Level the table carefully and clamp the spindle securely.

Place the alidade on the prepared support. Set it level by bits of wood, or the like, when its line of sight strikes the distant fixed point.

Locate two points in line on the table with the needle point a little less than the length of the rule apart. Also locate a point in line 40 or 50 feet beyond the table.

Transfer the alidade forward, as it stands, to the table with the edge of the rule at the points located on it.

See if the distant point and the near point are now in the range of the line of sight, or both the same distance therefrom on the same side.

By means of the device for controlling the angle of the telescope axis with the edge of the rule, set this axis so the line of sight will strike the points named, or pass the same distance from and on the same side of both when the alidade sets on the line of the points on the table.

After the adjustment seems perfect see that the table has not been moved, by trying the line of all the points again from the alidade support.

In making this adjustment the alidade may be set over parallel to the line of the two points on the table, by pricking off equal spaces from them, so that, after sufficient trials, the line of sight will strike both points when the telescope axis is adjusted. This saves any estimating of the distances the two forward points are from the range of the line of sight.

8. Center of the board. Given on a previous page in the first part of the description of the use of the plane table.

9. Vernier to vertical circle. Adjusted the same as on a transit instrument.

10. Telescope level tube. Adjusted the same as on a transit instrument.

In the case of the 9th and 10th adjustments the alidade should stand central on the board, and close watch kept and frequent tests applied to be sure of the stability of the apparatus during the work of adjustment. J. B. DAVIS.

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SUPREME COURT DECISIONS.

The following abstract of Supreme Court Decisions rendered during the past year, is taken by permission from the American Digest, published by the West Publishing Co., St. Paul, Minn.:—

1. Where an inland non-navigable lake covers a portion of a section of land, and the Government survey designates the dry land in each subdivision as a fractional subdivision or lot, the purchaser from the Government of such lots acquires title to all that portion of the bed of the lake included in the whole subdivision.—Stoner v. Rice, (Ind.) 22 N. E. 968.

2. Where the patentee of "the north half of the south-east quarter, and that part of the north-east fractional quarter, of section 36," etc., "which lies north of the Kankakee river, containing in all 122.70 acres," conveys "the north-east quarter of section 36," etc., "containing 122.70 acres," the deed passes title to all of the land in said north-east fractional quarter lying south of said river.—Sphung v. Moore, (Ind.) 22 N. E. 319.

3. A patent for a fractional quarter section, which is bounded by a meandered stream, passes title to all land within the lines of said quarter section between the meandered line and the water's edge.—Sphung v. Moore, (Ind.) 22 N. E. 319.

4. Where two deeds in plaintiff's chain of title respectively define the boundary of the land "by the edge of the mill-pond," and as "the bank of said mill-pond," and defendant is entitled to pond as much land as the pond flowed at the time of his purchase, defendant may enter on land originally covered by the pond, but which has subsequently become dry land by the receding of the water, though plaintiff's deed on its face shows his line to be the center of the pond.—Holden v. Chandler, (Vt.) 18 A. 310.

5. The owner of land on a bay conveyed an acre at the end of the tract nearest the bay, described as follows: "Beginning * * * by the beach, running * * * along the beach to," etc. In the general description of the tract it was bounded "easterly by the said beach." The grantee was given the privilege of a road from the middle of the front of the lot to the bay, and also half the drift coming on shore in front of the lot, and all the other privileges of the beach were reserved by the grantor, who bound himself not to build any house in front of the lot. The courses and distances would not carry the boundary to high-water mark. *Held*, that the beach did not pass by the deed.—Benson v. Townsend, 7 N. Y. S. 162.

6. Where a deed conveys land "bounded and described according to" a certain survey, does not call for a river, but calls for a line run between certain points, designated by the surveyor as on the bank of a navigable river, and it appears that the lines of such survey exclude flats between high and low water marks, evidence *aliunde* is admissible that the bank referred to was an artificial dike; that the grantee had notice that the grantors reserved the flats; that the grantors refused to execute a deed expressly conveying the flats; and that the sale was expressly subject to the survey, as tending to show that the flats were excluded, whatever may be the presumption from the deed.—Palmer v. Farrell, (Pa.) 18 A 761.

7. A complaint was filed to quiet title to 150 acres of land lying on the south side of a fractional section. A surveyor was ordered to survey that quantity, to be taken the full length of the section from the east side thereof to a river as the western boundary, and extending far enough north to include 150 acres. The surveyor executed the order, and reported a survey, which was accepted, and the court entered judgment, wherein the land was doubly described by inconsistent descriptions. The first described it as in the order of survey, and the second by metes and bounds, by which, after beginning at the south-east corner of the section, and following the south line to the river, it ran up the river, with the meanders thereof, to a stake placed by said surveyor 19⅓ chains north of the south line of the section; thence running westerly, parallel with the south line, 53.04 chains, to

a stake in the east line of the section; and thence southerly with said line 9⅓ chains, to the beginning. The stakes were gone, but were shown to have been placed at points 19⅓ chains from the south line, thereby including 150 acres. *Held*, that the first description should govern.—Caspar v. Jamison, (Ind.) 21 N. E. 743.

8. Rev. Stat. U. S. § 2396, provides that "the boundaries and contents of the several sections, half sections and quarter sections of the public lands shall be ascertained" as follows: "All the corners marked in the surveys returned by the surveyor general shall be established as the proper corners of sections, or subdivisions of sections, which they were intended to designate; and the corners of half and quarter sections not marked in the surveys, shall be placed, as nearly as possible, equidistant from those two corners which stand on the same line. * * Boundary lines which have not been actually run and marked, shall be ascertained by running straight lines from the established corners to the opposite corresponding corners; but in those portions of the fractional townships where no such opposite corresponding corners have been or can be fixed, the boundary lines shall be ascertained by running from the established corners * * * to the water-course," etc. *Held*, that in surveying a lot bordering on a river the water-course becomes the boundary, and continues so, no matter how much it shifts by accretion, and conveyances of the lot pass all, including such accretion to that line.—East Omaha Land Co. v. Jeffries, 40 F. 386.

9. The facts that rapid changes in the banks of the Missouri river are constantly going on, and that 40 acres have been added to adjoining land, do not overthrow an averment of a bill to quiet title to such addition, on the ground of accretion, that it was by an imperceptible increase, where it was nearly 20 years in forming. —East Omaha Land Co. v. Jeffries, 40 F. 386.

10. Where a deed describes a lot conveyed as of a certain width, and a party-wall stands on the south line, the north line may be found by measuring the given distance north from the middle of such wall.—Warfel v. Knott, (Pa.) 18 A. 390.

11. Where the probate judge, in pursuance of the provisions of Sess. Laws, Colo. 1872, p. 191, relating to town-site lots in Denver, advertises and sells a lot bounded on an unnavigable stream, and on the same day, and as part of the same sale, sells the bed of the same stream to another person; the deeds for the two parcels being executed the same day, and containing the same recitals,—the intention thus shown to separate the ownership of the bed of the stream from the ownership of the lot will overcome the presumption that a deed to a lot bounded on an unnavigable stream carries the title to the bed of the stream to its center.—City of Denver v. Pearce, (Colo.) 22 P. 774.

12. An instruction that, in arriving at a boundary line as originally run, natural objects are controlling calls; artificial objects, second in importance; course, third, and distance, fourth; and that, where there is still uncertainty, that rule should be adopted most consistent with the intent of the grant, is correct. -Luckett v. Scruggs, (Tex.) 11 S. W. 529.

13. An instruction that the beginning corner of a survey is of no higher dignity or importance than any other corner, and that, "if there are well-known and undisputed original corners established upon the ground around the survey, they would control the other calls of the survey, which are conflicting and contradictory, if there are any such," is correct.—Luckett v. Scruggs, (Tex.) 11 S. W. 529.

14. Where neither the corners of plaintiffs' nor defendants' land are satisfactorily established, and there is a well-established and identified corner of another survey, from which, by following course and distance, defendants' survey can be constructed, such course should be followed, though the boundaries thus established include land within the boundaries of plaintiffs' junior survey.—Griffith v. Rife. (Tex.) 12 S. W. 168.

15. Where the beginning corner of a survey is the south-west, but the south-east corner is equally well identified, a charge limiting the jury to finding the unidentified northeast corner by the first and second lines from the south-west

corner, is erroneous, as the south-east corner is of equal importance, unless the line from the former corner was actually run and measured, and that from the latter not.—Scott v. Pettigrew, (Tex.) 12 S. W. 161; Lancaster v. Ayres, Id. 163.

16. An instruction making the importance of an established north-east corner, in locating the north and west lines of a survey, dependent upon the jury's belief that such western line was not run, is erroneous, as such corner has the same weight for the purpose in question, whether the western line was run or not.—Scott v. Pettigrew, (Tex.) 12 S. W. 161.

17. In the description of lands, as to questions of boundaries the rule is settled in Virginia and West Virginia that natural land-marks, marked lines, and reputed boundaries will control mere courses and distances, or mistaken descriptions in surveys and conveyances.—Gwynn v. Schwartz, (W. Va.) 9 S. E. 880.

18. The statement of the quantity of land supposed to be conveyed, and inserted in deeds by way of description, must not only yield to natural land-marks and marked lines, but also to descriptions in deeds by courses and distances.—Gwynn v. Schwartz, (W. Va.) 9 S. E. 880.

19. A call for a lot by the name or number which it bears on a plat of the land will prevail over courses and distances, and ordinarily over calls for monuments.—O'Herrin v. Brooks, (Miss.) 6 So. 844.

20. Where the descriptions in a deed refer to a survey and a map based thereon, making both a part of the deed, and there is a discrepancy between the map and the survey, the latter will prevail.—Whiting v. Gardner, (Cal.) 32 P. 71.

21. When a survey calls for the "Dougherty" survey as one of its adjoiners, an instruction that if the jury find that the "King" is the survey intended by the call for "Dougherty," the former being located, the call would furnish "some evidence" of the location of the survey in question, is insufficient, as such a finding would locate the survey in the absence of marks upon the ground.—Tyrone Min. & Manuf'g Co. v. Cross, (Pa.) 18 A. 519.

22. Where no marks are found on the boundaries of a survey, and it cannot be located on the ground, evidence of the location of junior surveys which call for the lines of the elder as adjoiners is admissible, as showing where the surveyors upon the ground located such lines.—Tyrone Min. & Manuf'g Co. v. Cross, (Pa.) 18 A. 519.

23. Where the court, in an action of ejectment, instructs the jury that, "after a survey of blocks had been returned and had remained in the land-office 21 years, it was conclusively presumed that it was run upon the ground, whether marks were found upon the ground or not," but in other portions of his charge repeatedly states the law to be that marks made by the surveyor on the ground are the first and highest evidence of the true survey, the instruction cannot, on the whole, be said to be misleading, as he will be reasonably understood to have charged that the presumption in favor of returns of surveys on file for 21 years is only applicable to such surveys where no monuments or marks on the ground are found to contradict them.—Grier v. Pennsylvania Coal Co., (Pa.) 18 A. 480.

24. The monuments or marks of the surveyor on the ground determine the true survey as against calls for adjoinders or courses and distances as returned; but, each block of surveys being separate and complete of itself, the call of a tract in one block for an adjoinder in another does not make the monument of the adjoinder the monument of the later block.—Grier v. Pennsylvania Coal Co., (Pa.) 18 A. 480.

25. Where a boundary line is assented to by the owner of a tract of land at a time when there is no dispute concerning such line, and on the supposition that it is the true boundary, he is not estopped, on discovering that such is not the case, from claiming title to the real boundary.—Schraeder Min. & Manuf'g Co. v. Packer, 9 S. Ct. 385.

26. Continuous and uninterrupted possession, under claim of ownership, to the line of a division fence, will not bar title, where it appears that such occupa-

tion was under a belief that the fence was on a true line, and without intention of claiming beyond the true line, as described in the deeds.—Skinker v. Haagsma, (Mo.) 12 S. W. 659.

27. Where a survey is referred to in a deed for greater certainty, it legally forms a part of it and both should be construed together.—Heffleman v. Otsego Water-Power Co., (Mich.) 43 N. W. 1096.

28. An exception in a deed which reads, "Except the dower of fifty acres, as fully described in the deed given the C. B. Co.," is not void, though the boundaries of the excepted land are not defined in any way, as reference may be had to the deed to the C. B. Co. to ascertain them.—McAffee v. Arline, (Ga.) 10 S. E. 441.

29. The exterior of two adjoining interior surveys were undisputed. The boundary line between them had never been surveyed, but its southern end was marked by an oak. North of these surveys were two others. These four surveys were originally returned as being of equal size, and having one common corner. The northern end of the line between these two latter surveys was marked by a sugar-maple; which was not directly opposite the oak, and it was proved that the northern line of these surveys was shorter than the southern line of the others. *Held*, that the boundary line between the two southern surveys should run from the oak parallel to the end lines, and not diagonally from the oak to the maple. —Bloom v. Ferguson, (Pa.) 18 A. 488.

30. The course of the eastern line of the H. tract, as given in the original survey made in 1745, was 14 deg. east. The course of the western line of the B. tract, lying immediately east of the H. tract, as given in the original survey made in 1813, was 17 deg. and 15 min. east. The western line of the B. tract was made of exactly the same length as the eastern line of the H. tract, and the beginning point of the two lines was the same. The difference in the course of the two lines could be satisfactorily explained by the change in the position of the magnetic needle which had taken place in the time intervening between 1745 and 1813. *Held*, that the two lines must be considered as coincident.—Scott v. Yard, (N. J.) 18 A. 359.

31. The owner of a lot in the city of Rochester, of the area of about one-half acre, rectangular in form, fronting 274 feet on a street, and abutting on the rear for the same distance on a canal, the location of both, as well as the other lines, being undisputed, conveyed a portion, by description, of "137 feet front and rear, measuring from G. H.'s north line on G. street, and also 137 feet from G. H.'s south line on the canal; being the piece of land occupied as a garden by the grantor." The lot was divided by a fence, one side being used as a garden; the fence starting on G. street midway, but striking the back line at the canal at a point 19½ feet from the middle of the lot. That fence was not mentioned in the deed. *Held*, that the reference to the garden was too indefinite to control the calls for exact distances from known bounds, and the divisional point on the canal should be located 137 feet from G. H.'s line.—Harris v. Oakley, 7 N. Y. S. 232.

32. Plaintiff owned a village lot, No. 124, and a tract of land lying adjacent thereto on the south and east sides. River street, which lay along a river's edge, was the westerly front of both the lot and the tract. He conveyed the tract to defendant, reserving a part thereof, beginning at the S. W. corner of the lot; thence south-easterly, along River street, 32 feet; thence north-easterly, "on a line with the S. E. corner of lot No. 124," 10 rods and 23 links; thence N., to M. street; thence W. to the N. E. corner of the lot; thence south-westerly, to the S. E. corner; thence to the beginning. Locating the beginning point at the S. W. corner of the lot as appeared by the village plat on the easterly side of the street, the line passed directly through the S. E. corner of lot 124, taking no part of the lot, and thus making the reservation wholly within the tract conveyed; but by beginning at the river's edge, on the westerly side of the street, on the theory that plaintiff's property extended to the river, subject only to the easement of the street, the line would pass through and take part of lot 124. *Held*, that the former location of the corner was correct.—Anderson v. Scott, (Mich.) 42 N. W. 991.

33. Lands are not surveyed lands by the United States until a certified copy of the official plat of survey has been filed in the local land office.—United States v. Curtner, 38 F. I.

34. A county surveyor, employed to restore the lines and corners of adjoining tracts of land according to the original government survey, found township corners only, then (the other quarter and section corners being missing) ran a straight line from one township corner to the other, and on this line placed the quarter and section corners, but did not take any testimony to ascertain the lines or corners of the original survey, did not attempt to prove his lines or corners by re-establishing the missing corners from all the nearest known original corners, in all directions, did not sufficiently regard the field notes, and did not, where the original monuments had disappeared, regard the boundary lines long recognized and acquiesced in. *Held*, that such a survey is incomplete, and cannot be approved as the true and correct determination of the boundaries and corners as originally established by the Government.—Reinert v. Brunt, (Kan.) 21 P. 807.

35. Upon an issue as to the location of a line of the Government survey, evidence of the location of monuments is not overcome by field-notes of the original survey, taken at the time of the erection of said monuments or subsequent thereto.—Hubbard v. Dusy, (Cal.) 22 P. 214.

36. As between complicated descriptions of a line dividing two sections or quarter sections, that one is to be adopted which is most in conformity with the monument established by the Government survey.—Hubbard v. Dusy, (Cal.) 22 P. 214.

37. As between different monuments, those best identified should prevail, independent of anything in the field-notes of the original or any subsequent survey.—Hubbard v. Dusy, (Cal.) 22 P. 214.

38. Where it is doubtful which of two lines of monuments is the true Government line, other things being equal, that one is to be so considered which most nearly conforms to the field-notes.—Hubbard v. Dusy, (Cal.) 22 P. 214.

39. Testimony of declarations of a grantor, before the execution of a deed, tending to establish a boundary other than that made by the deed as construed by the court on appeal, is inadmissible, as its effect would be to convey land by parole in contravention of the statute of frauds.—Harris v. Oakley, 7. N. Y. S. 232.

THOMAS LOVE.

IT is with pain and regret that the secretary announces to the Society the death of one of its early members, Mr. Thomas Love. He was born near Hillsboro, Loudon County, Virginia, September 8, 1810. His parents were strict Quakers, or Friends, as they called themselves, and he was raised in that faith. In 1829 he attended the inauguration of Gen. Jackson, as President of the United States. He was in Ohio in 1830, and soon after came to Michigan and settled at Berrien Springs, where he was engaged in mercantile business for several years. He was Deputy County Treasurer of Berrien County from 1838 to 1840: in the latter year he was elected County Treasurer as a Whig, while the Democrats had a majority of one hundred on the general ticket. In 1844 he was elected County Clerk and held the office two terms. After this he went into the lumber business near Berrien. In 1854 he located at Avery, and, in company with another gentleman, built a saw mill which did a large business for many years, after which he engaged in farming and surveying. He was twice elected County Surveyor—in 1872 and 1874—and held various township offices. He was an efficient and popular officer, and was several times elected over adverse party majorities. He made a survey of the city of Niles and did his work so thoroughly that the surveys and monuments in that city are in the best condition of any city or village with which the writer is acquainted. He was agent for the Michigan Central Railroad at Avery for thirty years, and American Express Agent for twenty-five years or more. He was one of the founders of the Michigan Engineering Society, and always took a most active interest in it till the last. He did a large amount of work in the collection of material for the Manual of Land Surveying, and did everything in his power to advance the interests of the society. His dues were always paid in advance, and an extra dollar generally came with it. One of his last acts was to send the timber scribe to the writer for exhibition at the Detroit convention; he was then unable to sit up, and knew that he should never meet with us again. He died February 24, 1890, from old age, without disease or suffering. He was a gentleman of the old school, affable and courteous at all times. In the words of one nearest and dearest to him, "He was an honest, upright man, conscientious and truthful; what more can I say than that he was a gentleman in every sense of the word—one of nature's noblemen?"

F. HODGMAN.

THE ELEVENTH ANNUAL CONVENTION.

The eleventh annual convention of the Michigan Engineering Society was held at Detroit, January 21, 22 and 23, 1890. Owing to the general prevalence of *La Grippe*, a very considerable number of the members were absent who would otherwise have been in attendance. The earlier sessions were held in Philharmonic Hall, but on account of the light attendance it was concluded to hold the later sessions at the Plankinton hotel. A stenographer was employed to report the proceedings, but his report when received proved to be of very little value, and for this reason we are unable to publish any considerable part of the discussions. For the same reason Mr. Reed's description of work on the St. Clair tunnel is omitted. The business meeting of the convention was held on Thursday afternoon. The report of the secretary was read and accepted. The following is the report:—

SECRETARY'S REPORT.

I herewith submit the following report of business transacted for the Society since the last annual meeting. Everything up to the close of the convention at Lansing has been placed in the hands of every member of the Society in the columns of the Annual, and I do not deem it necessary to repeat it. In accordance with the orders of the Society, amendments to Article 3 of the Articles of Association were signed by the directors and filed in the office of the Secretary of State. The annual meeting of the Board of Directors was held at Hotel Downey, in the City of Lansing, October 9, 1889. There were present President Steele, Secretary Hodgman, Directors Cooley and Appleton. The meeting was called to order by the President and the ballots for officers canvassed. The following candidates, having received a majority of the ballots cast for the respective offices, were declared elected:—

President—R. C. CARPENTER.

Vice President—J. H. FORSTER.

Secretary and Treasurer—F. HODGMAN.

Directors—G. E. STEELE, M. E. COOLEY and C. E. GREENE.

The annual report of the Secretary was read and accepted. The directors examined the report and accounts of the Secretary and by M. E. Cooley reported that they found them correct.

The following is the report:—

SECRETARY'S REPORT FOR 1889.

I have to report the following business transacted by me for the Society since the last annual meeting:—

The first business after that meeting was to complete the program and make preparations for the annual convention. The list of papers selected at the annual meeting was provided for, as far as it was possible for the Secretary to do so. Circulars of invitation to civil engineers and surveyors throughout the State were prepared and sent to all whose addresses could be procured. A concession of special rates for the convention was secured from the Michigan Railway Association. The local arrangements for the convention were provided for by the Lansing members. It is not necessary to speak of the very successful convention which was held. At its close bids were solicited from various firms for the publication of the annual report. The job was let to the Review and Herald Printing Company of Battle Creek, on a basis of $240 for 1000 copies of 150 pp. each. Extra pages to be $1.25 per page, and cuts and extra work to be paid for by the Society. The report was out in May, and I took the liberty to christen it the Michigan Engineers Annual.

Letter ballots for new members and for officers were sent out early in the year, and the ballots for new members canvassed by me in time to include their names in the Annual. Certificates of Membership were made out and mailed to all new members the 1st of June. One copy of the Annual was mailed to each member of the Society not in arrears for dues, as soon as it was out. Copies were sent to others at subsequent times as fast as their dues were paid. Copies were also sent to all of our advertising patrons. Exchanges of reports have been effected with the Societies of Arkansas, Iowa, University of Michigan, and with the Provincial land surveyors and Dominion land surveyors of Canada. I have written the secretaries of the Missouri and Ohio Associations without getting any reply. The Indiana reports are late, but we expect them some time soon.

A good proportion of our income is derived from our advertising patronage, and without it our annual reports cannot be made what they have been. The Secretary has labored diligently both to secure such patronage, and to make the reports worthy of it, and I wish to especially acknowledge my obligations to Mr. Geo. L. Wells for the assistance he has rendered. If the members generally had been the tenth part as willing and helpful as Mr. Wells has been, we should have had the means of adding greatly to the value and attractiveness of our Annual. As agreed upon in the convention, the proceeds of a special contribution by the members was used to secure a portrait of Ex-President J. B. Davis. This was procured of the Eastman Dry Plate Company of Rochester, from a negative taken in Ann Arbor.

Some time a o a communication was received from a committee of the American Society of Civil Engineers, requesting the appointment by this Society of a committee to confer with them on the subject of preparing a plan of affiliation with the American Society, the committee to report to that Society by the 1st of November. I replied to the communication, notifying the writer of the time and place of our annual meeting, and requesting further information in regard to what the American Society desired. No reply has been received.

Notice of the annual meeting has been sent to each member of the Society, with a request for a response to it relative to place of meeting, subjects for discussion at the next convention, etc. I herewith submit such responses as I have received.

I also submit the following in regard to the finances of the Society:—

RECEIPTS.

On hand October 10, 1888	$ 111.85
Received from advertisers to October 9, 1889	234.95
Received from members for dues	221.00
Received from members for portrait fund	43 62
Received for Reports sold	7.25
From Wm. Appleton	50
	720.17

EXPENDITURES.

Paid balance on 1888 Reports	$ 92.04
Paid 1889 Reports and Portrait	359.57
Paid Stenographer	35.00
Paid Secretary's Salary 1888	50.00
Paid for Expenses on 1889 Reports	13.50
Paid for Stationery and Postage	48.44
Paid for Printing	27.08
Paid Expenses of Directors at Lansing	9.67
Paid for Express and Freight	12.30
Paid for American Digest	10.00
Paid for R. R. Certificates	1.00
Balance on hand October 9, 1889	61.57
	720.17

There is also due the Society from members for membership fees and dues and advertising $45.35.

No reports have been sent to members who are indebted to the Society, with the exception of new members who are only indebted for the senior membership fee. F. HODGMAN, *Secretary.*

The Secretary filed notices of sundry proposed amendments to the constitution and by laws. It was voted to hold the next convention at Detroit, beginning January 21, 1890, and the members in Detroit were appointed a local committee of arrangements.

The Secretary presented a list of topics furnished by members of the Society for discussion at the next convention, including papers promised by several members.

It was voted that the Secretary prepare the program for the convention.

The Board of Directors then adjourned. F. HODGMAN, *Secretary.*

Since the meeting of the Board of Directors I have endeavored to the best of my ability to carry out their wishes in preparing for this convention. In view of the repeated refusals of the Michigan Railway Association to grant reduced rates to Society meetings of various sorts, I did not deem it worth while to apply for special rates to this convention. I have made partial arrangements for printing the next number of the Annual, and have done something toward securing advertisements for it. Here I wish to repeat what has been said several times before, that it is very desirable that all the members of the Society who can, should co-operate with the Secretary, or publishing committee, in securing advertising patronage. Upon the amount of advertising secured, very largely depends the quality of the reports sent out as well as the number published. It was very much desired to publish in the last Annual a number of cuts illustrating the papers. It would add very much to the value and attractiveness of our Annual if we could with each number publish cuts illustrative of engineering work performed during the year by our members or others, and if we could have them from photographic negatives taken by ourselves so much the better. It is desirable to increase the circulation of our Annual by increasing

the number of our exchanges, thus increasing the value of the Society to each member by the additional amount of engineering literature furnished, and at the same time increasing the value of the Annual as an advertising medium. Something of this would have been done the past year if the finances of the Society had permitted, but it was thought better to keep entirely within our means, and incur no obligations that we were not sure of the means to meet. So we want each one of you to do what you can to secure advertising patronage; and not only that, we want you to help to keep that patronage by making it worth the while of these firms to advertise with us, by patronizing them in turn whenever we have the opportunity.

The late numbers of our report have been copyrighted. I think it would have been to the advantage of the Society if it had been done from the first. Authors all over the country have been using our work without giving us credit for it. If it is of value to them, they should pay us for it. In this connection I would suggest the question as to whether it might not prove profitable to the Society to classify the papers which have been published in the Reports and publish them in book form in several small volumes. F. HODGMAN.

Since writing the foregoing, I have received the proceedings of the Ohio Society of Engineers and Surveyors, and mailed them to all members of the Society not in arrears for dues. With them I sent the Dominion Land Surveyer's Report, which, by an oversight of my assistant was not included with the other reports when sent out. The Indiana report is the only one of our exchanges which has not been received. I learn that it has not been published but goes over to be published with the 1890 reports. After the past year's trial, I am inclined to think it is not the better way to send out reports by express at the members' expense unless they furnish the money to prepay charges. If this were done they could be sent to most of the members at a trifle less than by mail if sent in packages of four pounds or less. The postage is the second largest bill the society has to meet. It amounts to nearly $15. on the Dominion and Ohio reports just sent out. In connection with the photographic work of the Society it seems that it would be a good plan to have an exhibit at our next meeting of photographs by the members of the Society, and if we can also have a lot of lantern slides illustrating the work done by our members it would be a very valuable and attractive part of our program. Can we not have them?

The *Engineering News*, the *Railroad and Engineering Journal*, and the *American Engineer*, have been sent to the Society during the past year in exchange for our Reports. Every engineer should have one of these journals, and all of them, if he can afford it.

F. HODGMAN, *Sec'y.*

The following Amendments to the Constitution and By-Laws, which were submitted to the Board of Directors at their annual meeting, were submitted to the convention and adopted:—

AMENDMENTS TO CONSTITUTION.

ARTICLE II.

SECTION 1. The officers of this Society shall be senior members. Nominations for office shall be made at the annual convention. Election shall be by letter ballots, which shall be submitted to the Society previous to the next annual meeting of the Board of Directors. The ballots shall be canvassed and the result announced by the Board of Directors at their annual meeting. Officers of the Society shall hold their respective offices until the close of the annual meeting of the Board of Directors, and until their successors have notified the Secretary of their acceptance of the offices to which they have been elected.

ARTICLE IV.

Amendments to the Constitution shall be presented in writing at the annual convention, and submitted to the Society by letter ballot previous to the next annual meeting of the Board of Directors. The Ballot shall be canvassed, and the result ascertained and announced by the Board of Directors at their annual meeting.

AMENDMENTS TO BY-LAWS.

BY-LAW No. 3.—*Relative to applications for membership.*—The applications must be favorably indorsed by at least one member of the Society from personal knowledge, and be accompanied by a fee of $3.00. The application and fee shall be delivered to the Secretary, who shall refer the application to the Board of Directors for examination and approval. If approved by them, the Directors will determine to what class the applicant is eligible, and endorse their approval and classification on the application, which shall be submitted to the Society for action by letter ballot. Five adverse ballots shall reject a candidate. In case of the rejection of a candidate, the Secretary shall immediately return the fee to the applicant. If the candidate is elected, he shall sign the constitution, and if elected a senior member, shall pay the further sum of $2.00 as a membership fee. No additional fee shall be required from junior members. When a candidate is elected to membership, the Secretary shall give him notice to that effect, and upon receipt of the fee as above provided, shall issue to him a certificate of membership.

Letter ballots for members shall be issued to the Society by the Secretary on the first Monday in March of each year. The ballots shall be canvassed by the Secretary and the result announced to the candidates for membership on the first Monday in April of each year.

Candidates who have been elected to membership and fail to pay the membership fee within thirty days after being notified of their election, shall forfeit their membership and the application fee. The Board of Directors may extend the time for payment in any instance where satisfactory reasons are shown therefor.

BY-LAW No. 5.—Members desiring to withdraw from the Society shall make application in writing to the Secretary, paying all assessments and dues to the Society up to the time when the application is presented. The application shall be referred to the Board of Directors, who shall determine whether the application shall be granted or refused.

No member shall be liable to pay any dues or assessments levied after the time when his application for withdrawal is received by the Secretary until it is passed upon by the Board of Directors.

The following persons were nominated for officers for the next year:—

For President—R. C. CARPENTER, Lansing.
JOSEPH RIPLEY, Sault St. Marie.
J. B. DAVIS, Ann Arbor.
WALTER S. RUSSEL, Detroit.

For Vice-President—GEO. L. WELLS, Cadillac.
J. H. FORSTER, Williamston.
E. DENNIS, Jackson.

For Secretary and Treasurer—F. HODGMAN, Climax.

For Directors—GEO. L. WELLS, Cadillac, M. E. COOLEY, Ann Arbor, W. B. SEARS, East Saginaw. C. E. GREENE, Ann Arbor, GEO. E. STEELE, Traverse City, S. E. JARVIS, Lansing.

Applications for membership were received from the following persons and approved by the Board of Directors for Senior members: —

ADOLPH BARTHEL, Detroit, Mich.
G. S. WILLIAMS, " "
E. H. MUMFORD, " "
FRANK S. BIGLER. " "
MILO DAVIS, East Tawas, Mich.

The thanks of the Society were voted Mr. Walter S. Russel for the very acceptable manner in which he had provided for the local wants of the Society; to Mr. Clark, proprietor of the Plankinton Hotel, for many courtesies extended; to the Eastman Company of Rochester, for their exhibit of instruments, and to their representative, Mr. C. A. Stacey, for his demonstration of the manner of using the camera and making bromide prints. On motion of Mr. Forster, the sum of $50 was voted to the Secretary, in recognition of his services.

Mr. Livingstone read a paper, giving the results of tests of the engines of the steamer T. W. Palmer, during one of her regular trips.

Mr. Hyde exhibited some fine drawings and blue prints, and explained methods used in preparing them. The papers of Messrs. Livingston and Hyde were not furnished the Secretary for publication. The Society adjourned *sine die* on Thursday evening.

SUGGESTIONS OF THE SECRETARY.

1. When letter ballots are sent you, read the instructions and prepare your ballot in the manner directed, or you are liable to lose your vote, as many have done by their carelessness.

2. Have you done anything for the Society except to pay your fees and dues? If not, let us have a paper from you at the next convention. The active members of the Society are not doing their work for the $2 a year dues. They want the thoughts and experiences of others in exchange for their own.

3. Photographs are excellent for preserving records of engineering work. Let us have an exhibit at the next convention.

4. Lantern slides furnish the most satisfactory means of exhibiting views. They are not hard to make. Let us have an exhibit of views of our own make at the next convention.

5. What subjects would you like to have discussed at the next convention?

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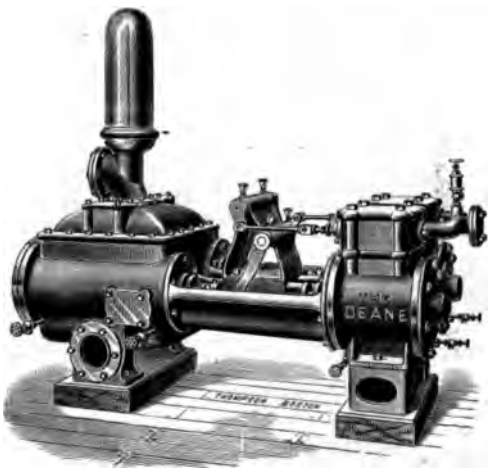

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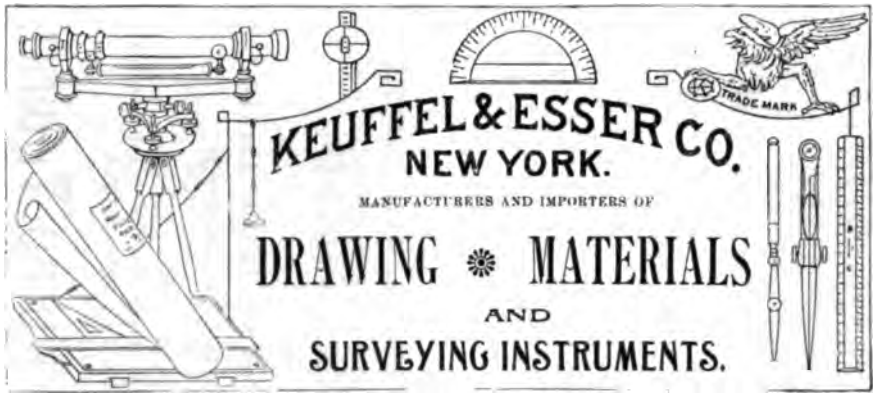

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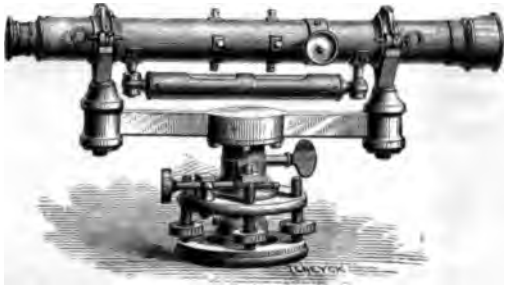

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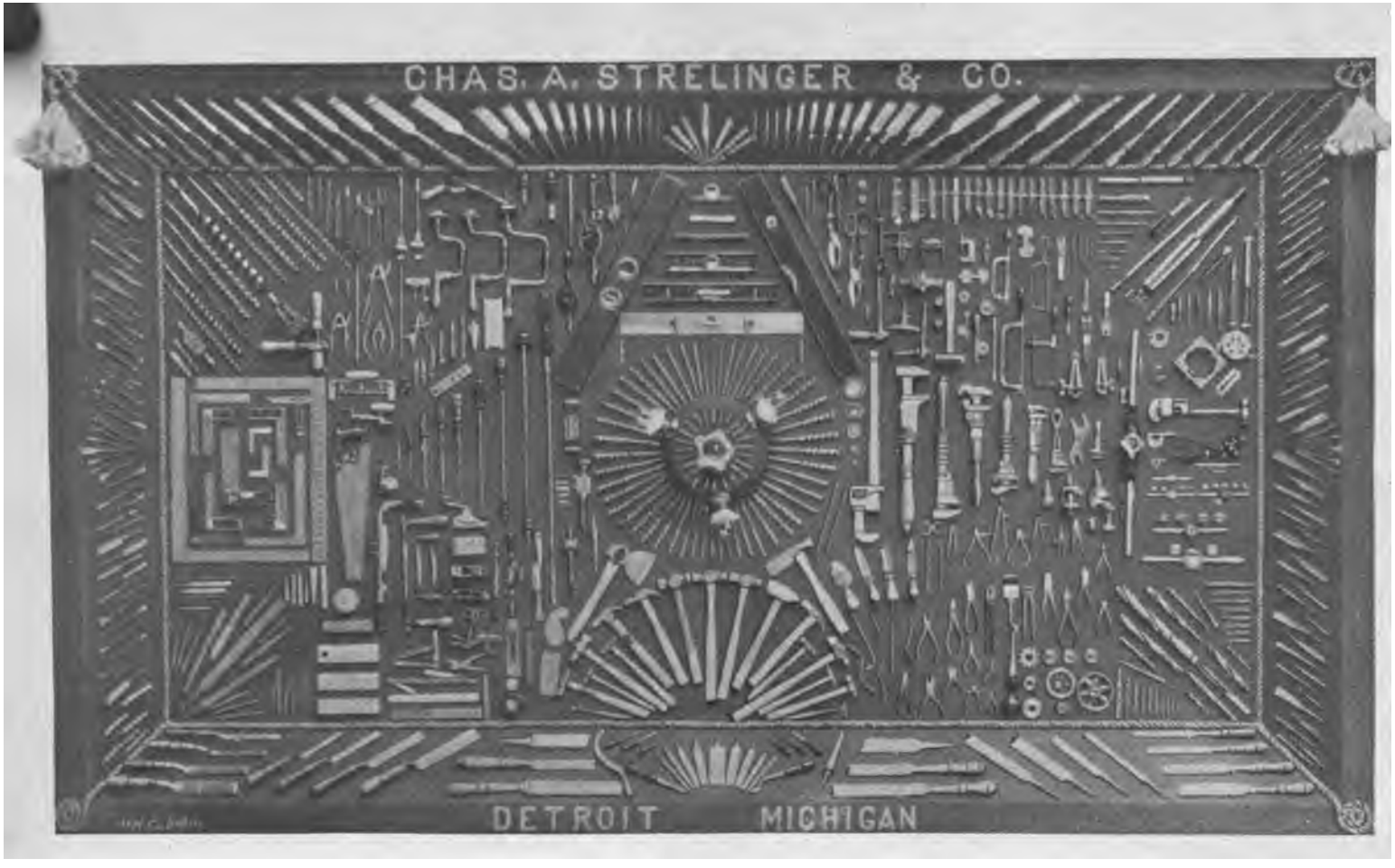
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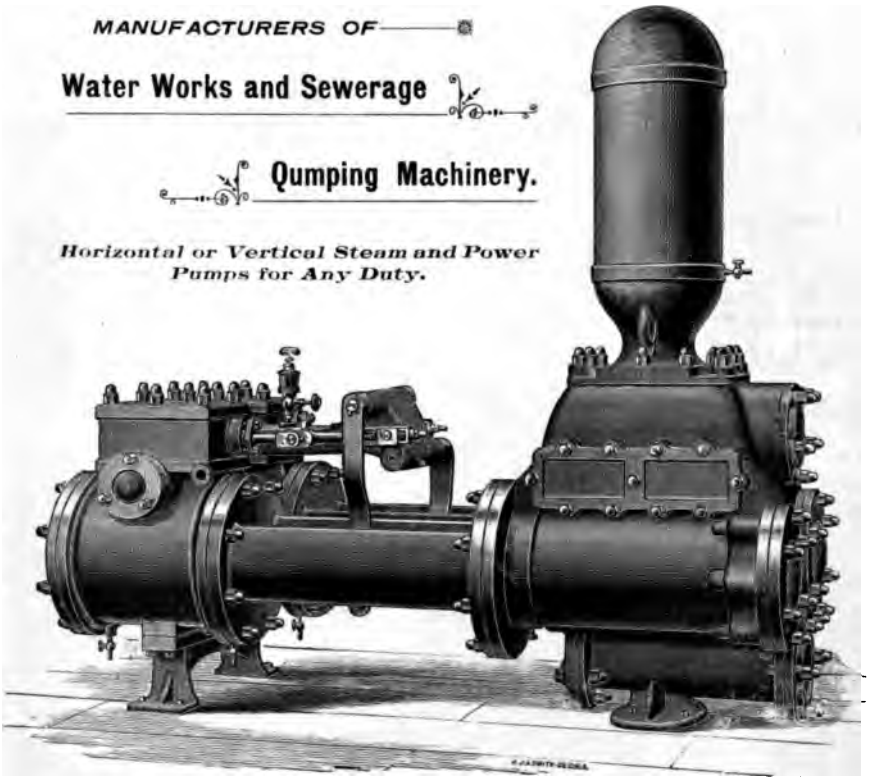
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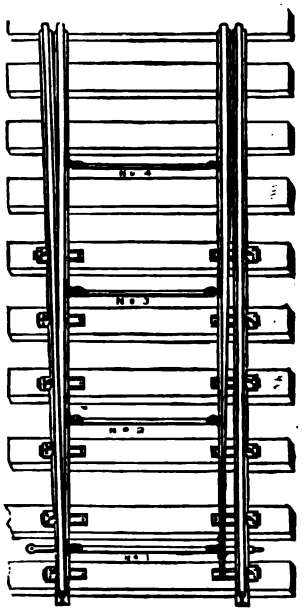

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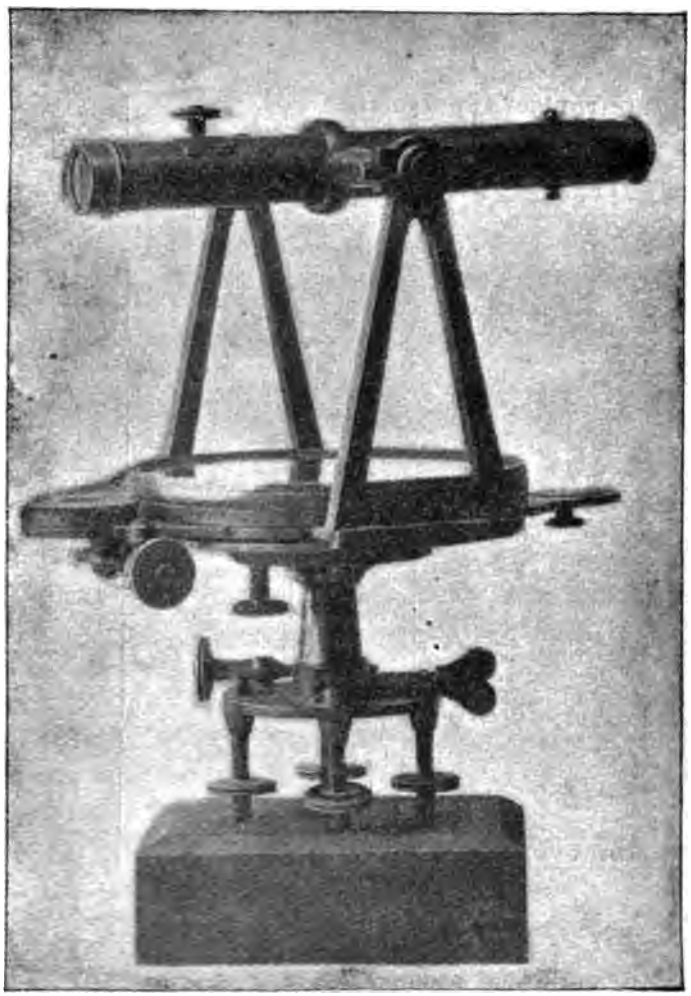

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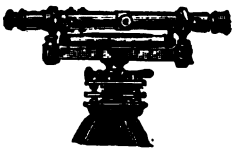

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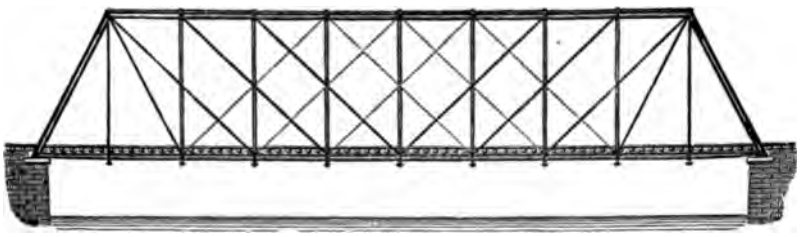

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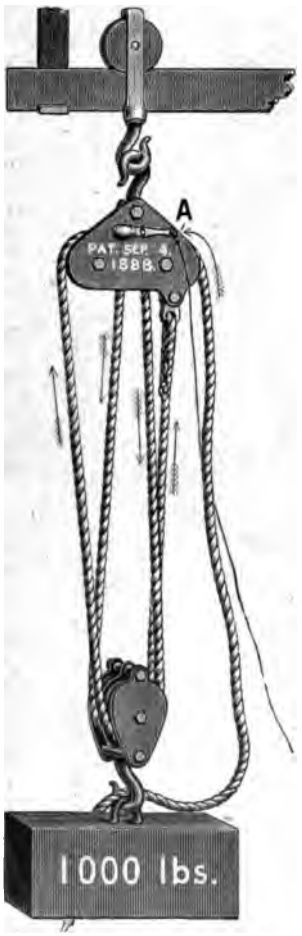

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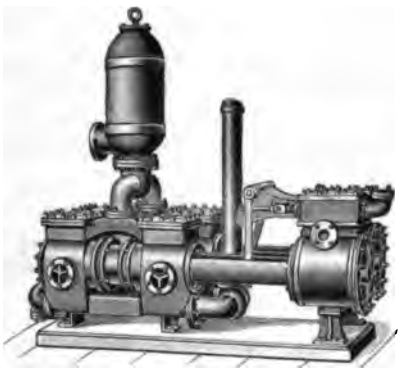

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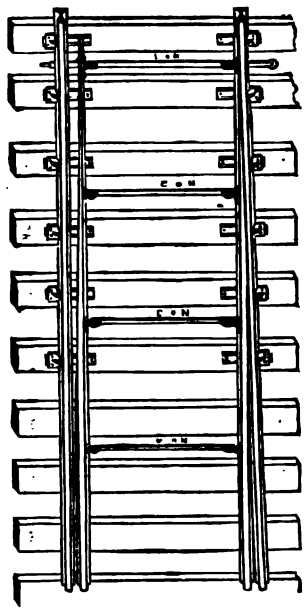

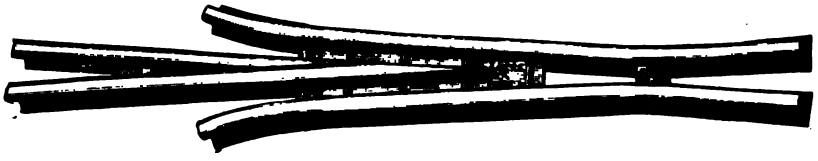

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PAPERS AND DISCUSSIONS

At the Twelfth Annual Convention of the Michigan Engineering Society, held at Lansing, Jan. 20–22, 1891.

THE EXPLORER AND HIS WORK IN THE COPPER REGIONS OF LAKE SUPERIOR.

THE existence of copper in the upper peninsula of Michigan, was known long before the researches of Dr. Houghton had brought the fact clearly before the public. Whereas float copper had been found in many places, it was reserved for our able State Geologist, just named, to demonstrate that native copper would be found *in place* and profitably mined.

The publication of his reports gave rise to a lively interest in the remote, little-known region, washed by the waves of Lake Superior, so that men lost no time in reaching those shores supposed to contain unlimited wealth.

It is not my purpose to write a history of that crusade, wonderful in many respects. It was the precursor of that greater crusade, which followed upon the discovery of gold in California. It was in reality the beginning of that intense activity, mental and material, which has characterized the last fifty years of our national development, beginning at the close of the Mexican War.

But my aim is, in this paper, to show how old-time, practical copper hunters did their work. A surveyor who undertakes to survey a country, likes to reach a commanding point, whence he may view the whole field, and fix in his mind a general idea of its outlines and topography.

In imitation of this discreet person, the writer must pause a moment to give you a brief description of the copper region, as traversed by our explorer.

DESCRIPTION.

The copper-bearing rocks on the main-land in the Upper Peninsula, lie in a narrow belt averaging from three to four miles in width, and 150 miles in length, starting from the northeastern extremity of Keweenaw Point, and ending near the Wisconsin line on the west.

Isle Royale, on the north side of the lake, is also a copper-producing section.

The country, when discovered by the white man, was clothed with a luxuriant forest, the prevailing timber being pine, maple, birch, hemlock, fir, and cedar. The underbrush was almost as dense as a jungle. The surface of the country on the trap ranges, is, generally speaking, rough and broken; knobs and ridges have an elevation of from 400 to 1,300 feet above the lake. The streams are short and swift, and small lakes frequently occur. There is much level land, and extensive cedar swamps. Most of the country is covered with a deep drift of bowlders, sand, and gravel, with some clay.

Many of the rocky ridges are very picturesque, presenting ragged escarpments on their southern faces, and sloping off gently to the north. This feature arises from the fact that the whole trap range has been elevated from its horizontal position, and tilted up, the south side of the range being the higher and bolder, the descent or inclination of the beds being in the direction of Lake Superior, which is an immense trough, the rocks or beds of the same character on Isle Royale dipping to *the south* toward the center of the lake, just the reverse of those on the south shore or main-land.

The line of cliffs in Keweenaw county, at the point where the once famous Cliff mine was developed, offer a good example. This bold range rises out of the main range, and is several miles long. When viewed from the south, it gives one an idea of an artificial battlement, constructed by giants, of course; its perpendicular walls, more than 100 feet high, swelling out and retreating, yet conforming to one general plan line. The rocks are what is known as greenstone, a fine-grained, crystalline rock. The face of the

cliffs presents a good example of the step-like formation of trap; it looks as though composed of huge square blocks of stone solidly set, but not brought to a regular even face. One may climb up these steps with more or less ease, but the attempt would not be particularly inviting. The weathering for ages has added much to the picturesque in the cliffs.

The cliffs appear lower than they are, on account of the immense accumulation of débris at their base, thrown down by water and frost. They are crossed by heavy fissures, having a northerly and southerly trend. These fissures are now filled with mineral matter deposited by mysterious currents, probably electrical.

The great Cliff mine was based upon one of these fissure veins. The copper, produced in such quantities as to enrich the proprietors, was what is known as mass copper. It was found in the vein imbedded in calcareous matter, in great lenticular masses, often hundreds of tons in weight. It was cut under ground, with large chisels, in pieces convenient for hauling — say from four to eight tons each. The matrix, or vein stone, so called, was beautiful spar, taking many crystalline forms, and sparkling in the candle light like the gems in Alladin's Cave. Much native silver, white and lustrous, was found associated with the other minerals.

Greenstone cliffs are common in Keweenaw county. Ridges of similar character but not of the same mineral structure, are found in Ontonagon county. None occur in Houghton county, the surface of that county showing but little denuded rock in elevation.

For this reason, this county, though now the greatest copper producing district in the world, was kept in the background. The deep drift overlying the rocks hid the veins and lodes from the casual explorer. The field was not inviting, and so Keweenaw and Ontonagon counties, being more favorably conditioned, received the attention of the first settlers, and took the lead in mining.

It required thorough examination and digging to find many of the lodes in Houghton county, but they were known to be there somewhere. Tell-tale floats found in the woods — vein-rock containing copper — hinted at mother beds beneath the soil. In the hills, flanking Portage Lake, veins were first found and opened.

Rich pieces of broken vein-stone — conglomerate and amygdaloid — found in the leaves in the woods, led to the discovery of the Calumet mine. But the belt or conglomerate lode was found only after digging 25 feet through sand and gravel. And in

this very pit remains of ancient explorers were found — birch-bark baskets, stone hammers, copper tools, and charcoal. But more of this farther on.

The Calumet and Hecla is founded upon a belt of conglomerate running *with* the formation, hence is wholly unlike the cliff fissure, before mentioned. The copper is also in a different shape. I beg to say, once for all, that all Lake Superior copper mined, is native or virgin copper, not an ore. At the Calumet it is what is technically called stamp copper, that is, the metal occurs in the gangue in flakes and shot-like forms throughout the whole lode, and is extracted by means of stamping and working. This in the richer deposits; in the poorer parts of the lode are barren places. There are no mass veins in Houghton district. The Franklin and Quincy mines and others not working, are based upon amygdaloidal belts, running with the formation, about N. 32 East, of enormous width — say from 20 to 50 feet — while the Calumet is, say, 15 feet, and the cliff fissure, three feet. Besides rich stamp work, these mines raise much small mass work, running up into tons. These belts contain a great variety of beautiful minerals for the cabinet.

The Huron and other mines, on the south side of Portage Lake, are found in what is termed epidote-quartz vein-matter, instead of calcareous rocks. Much small mass copper is found here also, but the chief dependence of the miner is on stamp copper.

The Atlantic mine on the same side of the lake, on the Quincy group of rocks, is still different in character. The vein-stone is a chocolate-colored, soft rock, with shot-copper lying all through the mass, with very little heavy metal.

In Ontonagon county have been found many stamp lodes with epidote and quartz, as the characteristic vein matter.

But the well-known Minesota lode was of a different character from any heretofore enumerated. It was a mass lode, but not a fissure vein, like the cliff. Its course was *with* the formation, like the Calumet and Quincy lodes, and, like the Calumet, the copper was associated with conglomerate, but it is a *contact* lode: that is to say, the enormous masses of copper found in it, reposed between the conglomerate bed and the trap of the country. This, in general terms; for really the copper was often found extending into the inclosing rocks

GEOLOGY.

The geology of the country, by taking a cross-section in Houghton county, is as follows: We find the low-lying country flanking the trap range quite level, underlaid by old red sandstone, in which are found valuable quarries. The timber is pine, fir, birch, and hemlock mainly, with cedar and tamarack swamps. At the junction of the trap and sandstone, the range presents a bold, steep front, cut by deep ravines, showing some beautiful water-falls and cascades. On the immediate shore of Lake Superior, fronting magnificent Keweenaw Bay, occur long lines of perpendicular, wave-worn, brown sandstone cliffs. Traversing the trap range from south to north, we find numerous belts of trap, varying in hardness and structure. But within these belts, and in conformity, but not blending, are found many strong conglomerate belts from 10 to 50 feet wide — the wreckage of pre-existing formations — wave-washed, smooth, rounded bowlders, cemented into a solid mass. This is a very curious feature, and a study, giving rise to many pressing thoughts as to the age of the trap rocks, the manner of formation or deposition, as well as the character of the prodigious forces which uplifted the range and changed the structure of some of the rocks. On the north side of the range we find flanking it, metamorphic sandstone, hard and with a metallic ring under the hammer. Did fire change this rock? Are the trappean rocks belts or beds of sedimentary origin? How did those numerous conglomerate belts find their place at different lines throughout the three-mile-wide mass of trappean rocks? But this is no place for a discussion of these interesting questions.

Concluding his general description and having reached the vantage point sought for, the writer will now proceed to show, as well as he can, how the old explorers went to work to find mineral veins and deposits of copper, thus opening the way to mining.

Our explorer, in the first place, must possess some such fitness as was displayed by Cooper's path-finder. He must be a good woodsman, hardy, self-reliant, brave, and sharp-eyed. He must be strong enough to carry a pack on his back, filled with his blankets, provisions, frying-pan, tin cup, and camp kettle. His dress must be strong and warm, embracing a slouch felt hat, a heavy flannel shirt, a pair of strong pantaloons, re-inforced by bed-ticking, sus-

tained by a heavy belt, from which depend hunting knife, exploring pick, and pistol; with feet encased in shoe-packs or moccasins well stuffed with woollen cloths. In his pockets he carries a compass, some fish-hooks and lines, his pipe and plug tobacco, and a match box carefully secured. No good explorer will carry a pocket-pistol, or liquor with which to muddle his brain and sap his strength. A cup of strong tea is the best stimulant he can find, as he sits by his camp fire after a hard tramp.

The very first preliminary explorations were conducted by parties composed of six or eight persons, and Mackinaw boats, yawl boats with sails and canvas, were used in coasting. The chief business of the party was to hunt up mineral tracts, and secure them by "permits" from the government. A land surveyor and a geologist accompanied the party.

Explorers soon found out that the magnetic needle was untrustworthy on the trap ranges, where iron and copper disturbed it, and electric currents are strong. No accurate surveys could be made with a common compass.

The ingenious and ingenuous chief of our party, however, was equal to the occasion. His scientific attainments were greater than his knowledge of practical surveying. He suggested to the writer that the magnetic disturbance did not extend far above the surface of the earth, and if he would climb to the top of the highest trees and set his compass there, he could get the course of any given line by sighting forward to the next farthest tree he could see, then come down and proceed to find that tree by some occult way, climb it—and "go ahead." The writer admitted the novelty of the suggestion, and its scientific *ass-pects*, but hinted in return that a gorilla, who was a good climber, be secured as surveyor.

Geologists were in great demand: were considered indispensable. But it soon transpired that some of these gentlemen, if not charlatans, were mere book-men, with no knowledge of woodscraft, and with only such knowledge of minerals as an amateur could obtain in a museum. The "deep-tangled wild wood" was a terror to our geologist, and he could not be induced to quit the lake shore. So he abided in camp, and sent the surveyor and his other young men into the woods to explore and fetch back to him bags full of minerals for him to examine and analyze. As these young men were as ignorant of minerals or veins as sucking doves, much worthless trash was lugged in with infinite toil. For ex-

ample, the common quartz rock and iron pyrites were brought in as specimens of gold veins!

But such was the *modus operandi* of our distinguished geologist. Could any good thing come out of him? "Not much!" One expedition was a failure — nothing more. But there were compensations. The geologist was dropped out of our party, and our young men soon became skilled woodsmen — good practical mineralogists, and no mean adepts in geology. They at least knew copper-bearing rocks when they saw them, and could distinguish copper from other minerals.

Professionals ere long dropped out of the line, and practical explorers took the lead.

Do not understand that I say there were no good geologists in the country. There were many, such as Hubbard, Douglass, Jackson, Foster, and Whitney, Col. Whittlesy, and others.

In the exploring party there were several packers and axmen, who acted as boatmen on the water. They were remnants of the old fur-trading companies — Canadians, French, half-breeds, and Indians. In service they were first-rate men, used to the water and the woods, hardy, patient, cheerful, and enduring. But when they had access to whisky in the camp, they forthwith got drunk, and quarreled like wild beasts. After they became insensible, through debauchery or fight, our officers dragged them to the boat and threw them in, hoisted sail, and made for some distant stream or bay, and encamped for the night. When the men had sobered off, they resumed work with their former ready obedience.

These parties made long coasting voyages, often indeed, circumnavigating the great lake. But they made frequent stops, running into the mouths of small streams which afforded shelter. The boat was hauled out and covered with hemlock or spruce boughs. Thus she formed a store-house for surplus provisions. The packers were loaded with provisions and cooking outfit, and the whole party set out for the interior to explore the copper range. Days and weeks elapsed before the party returned to the boat. Meantime, they were supplied with provisions from the boat by the packers who were kept on the trail. They finally returned to the shore, and resumed their voyage to the next place on the program, and so on, to the end of the season. These lake voyages were generally pleasant and interesting, but often dangerous in stormy weather, causing much loss by drowning. But this somewhat

cumbrous and inefficient mode of exploring soon had its end. One result was derived from it: a general knowledge of the whole country was obtained, which aided subsequent researches.

We come now to individual enterprizes. Our practical explorer, inured to hardships and at home in the woods, took to the bush alone, or accompanied by one packer, who acted as cook and man Friday.

Some central, quiet nook in the heart of the mineral region to be examined, was selected for a camp, always by the side of a running stream. Here in the solitary, trackless forest a wigwam was made of poles covered with cedar or birch bark, or with evergreen boughs. The hut was just big enough for two, with no guest chamber. A fire blazed in front night and day, for warmth, for cooking, and for protection against prowling wild animals, such as the gentle porcupine, the lynx, and the black bear. The little streams were all teeming with small brook trout which, caught with our pin hooks, garnished the morning and evening meal of hard-tack, pork, and tea. A porcupine stew was had on select occasions. The woods were full of partridges, almost as tame as barnyard fowls. These, when dressed, we cooked on sticks stuck in the ground and inclined toward the fire.

Our evenings, after a hard day's scramble through the woods, were happily spent reclining on our beds or carpet of sweet smelling pine or spruce, smoking pipes and exchanging song or story. When quite alone, as was often the case, when his man Friday was away after provisions, the solitary explorer found his evenings rather lonely. The quiet, the hush, the profound stillness of the deep, dark forest were somewhat awful. The imagination was quickened, and the fancy began to cut up terrible capers. The fall of a twig was almost a catastrophe, and the breaking of a branch out there in the darkness, was almost an earthquake, while the unexpected and unearthly yell, like the wail of a lost spirit, of a prowling lynx, would curdle the blood in one's veins and make every individual hair on one's head, stand on end. At times, when in certain moods, the impressive silence of the solemn woods was too awful, and the oppressed soul must needs find relief in sobs!

The writer, however, spent many a happy and joyous day in the woods alone, in exploration. From May until August the mosquitoes and black flies interfered much with hisw ork, but after

they had lived out their blood-thirsty days, a season of peace and high enjoyment followed. Especially in the mellow October days, after the early frosts had burnished the forest panoply with a brush dipped in the rainbow, our delight was such as not to be forgotten now after the lapse of more than forty years.

Mounting some lofty knob, bare and bald as the writer's head, our explorer would throw himself upon the smooth, rain-washed rock, swept by the winds of a thousand years, — yea, of thousands upon thousands, with no account of the years it was buried under the old glacier a mile in thickness, — light his pipe, and dream. He sees over there in the south, stretching away to the horizon, mile upon mile, a forest of green and gold and purple and yellow and scarlet, a solid mass of foliage basking in the soft sunshine. This variegated carpet from Nature's great artistic loom, soft and pleasant to the eye as a Wilton, is only broken here and there by some protruding knob, or intervale through which winds, with many turns, a silver stream, now lashed into foam by envious rapids, now leaping over a precipice, but still seeking its way persistently to an outlet where it may hide itself in the bosom of the great lake.

Reversing his outlook, he beheld far off, and far below, the broad blue expanse of Lake Superior, the mother of lakes and streams gigantic, sleeping quietly, and gaining strength in repose, for the battle to come with winter elements. Not a ship or speck dots the silver expanse, and solitude seems to reign on the water as well as on land. Nature, without man and his busy ways and inventions, seems as lonely and incomplete as was the first man in the garden of Eden.

Now the summer fly, benumbed by last night's frost, drones lazily in the air; a soft breeze stirs the leaves; the pipe drops from our explorer's mouth, unheard upon the rock; sleep wraps all his senses in oblivion. But a short clap of thunder awakes him; the sky is overcast, and great rolling, swaying thunder-heads, bellowing in their anger, and shooting out zig-zag flames, are seen in the south-west, unmistakable warnings that he must speedily seek his camp for shelter. A rapid tramp down the steeps and through the woods brings him home none too soon. The rolling and crashing of thunder above the tree tops is appalling. The woods are pitchy dark; the trunks of the trees, revealed by the glaring lightning, look like spectres. The wind howls, and the aged tenants of the

forest go crashing down. Broken limbs fall to the ground dangerously near. At first, in the wild hubbub of nature, no rain seems to fall. The dense foliage arrests it; but too soon it comes pattering down, at first gently, then in floods. The rude wigwam is no defense against such a down-pour, and our explorer, without fire, without light, sits disconsolate, wrapped in his drenched blankets, wet to the skin. The storm soon passes, and the thunder is heard far off over Lake Superior. But our explorer cannot kindle a fire with wet sticks, so he wraps himself tighter in his wet blankets and says, philosophically, to himself, "I am in for the night."

Occasionally our surveyor in the midst of his labors is caught out in a snow storm. His miseries entailed by wading in the snow, handling rocks in the snow, building a fire in the snow, and sleeping in the snow, are such that he likes not to dwell upon them. He prefers always not to harbor the unpleasant things of this life in his bosom, but to let them "*slide.*"

Our explorer is reminded by his conscience just here, that it might be the wish of his hearers that he would attend a little closer to the business in hand. Bowing to the admonition, he will now show you his way of exploring.

The first aim of the explorer was to make preliminary examinations of the particular tracts. If the section lines had been marked, his work was easier. He had only to find a corner, and assume one of the lines as his base. Pacing south, say twenty rods, he would stop to hack a tree, then start due east by compass, pacing the distance as he advanced. The writer's practice was to take short easy steps of two feet, and as he went on, keep count in his mind of every step. This mental effort soon became automatic, not hindering the use of eyes or hands. A note-book was carried, in which the topography was sketched, with full notes of every ridge, depression, outcrop, or stream, as well as the character of the rocks seen. When any outcrop demanded more than a passing examination, a pause was made, a tree in line notched with the pick, and distance from starting point noted down; a divergence was then made right and left, and a careful examination of the rocks for valuable minerals was made. Returning to the hacked tree, our explorer resumed his east and west line, keeping his eyes open to anything of importance. The mental tally for a mile having closed, he would look out for the section line. After long practice, he rarely failed to find the line at once. The next step

was pacing down the line twenty rods, then going west in the same manner as before, repeating the operation until the whole section was thoroughly gone over.

Such full notes were obtained that when he reached camp, or the office, he could plot them, and obtain a topographical sketch, including the geology and mineralogy of the section. Should any vein or lode have been discovered, its position was fixed so as to be readily found at some future time.

A more general survey was made by starting from known points in a township; and by compass line and pacing, and checking upon corners, a reconnaissance was made of prominent ranges and outcrops. Where the country was not subdivided, connection by compass and chain, with some prominent point on the lake shore, as a bay, mouth of river, etc., had to be made.

After much practice, our explorer became quite expert, not only in woods-craft, but in finding valuable mineral deposits. He acquired much of the skill possessed by an Indian in following traces and indications. The deep drift and soil overlying the rocks in places, called for the exercise of much patience and ingenuity. He must know the character of any rock found on the surface, and whether it was likely that it belonged to the hidden beds; or whether as a traveled bowlder it had come from a distance. If a bowlder, he must understand how it came there, as, also, the direction it had come from. Observation as to glacial scoremarks on denuded surfaces, give the general course of the ice currents. If the interesting bowlder, or "float," has been torn from copper-bearing rocks, like amygdaloid trap or conglomerate *in place*, he decides that it is a vein rock. Should some speck of metal be found, after chipping or breaking the "float" with the exploring hammer, the interest is greatly increased. The next question to be solved is, How far has this bowlder traveled? If it is hard, smooth, and rounded, the conclusion is that it has come from a distance, no one knows how far. But if the rock breaks easily under the hammer, is angular, and little worn, then the conclusion is that the mother vein or lode is not far away. The explorer now pulls out his compass, and ascertains which way northeast is from his position. He follows this course slowly, like a hound, turning over with his pick, and critically examining every stone in his path. As he proceeds, the number of stones multiply, vein-matter is more abundant, and is richer in copper. Finally a little further on, the whole

surface of the ground is covered with vein débris. Still, passing beyond this point, to his surprise he comes to smooth ground, with no stones to be seen. He now goes back to the point where bowlders were strewn the thickest, and says, The lode must be somewhere near here; for the fact that I found no bowlders farther east, is conclusive evidence that it is not *there*.

Where to sink a test pit now exercises his best judgment, and the question requires much thought. He wishes to strike the lode as soon as possible, without unnecessary digging; for exploring with pick and shovel is slow, costly work. Finally he assumes a point south of the supposed position of the vein to be discovered, and orders his men to sink there. After he gets down a few feet, he finds that the mass of bowlders lie on an incline plane; that the vertical depth of the débris is greater right near the vein, and that, as you recede from it, southwest, the débris grows shallower, until it runs out, the moving force, the glacier, having pushed that way, dropping its wreckage in the order named. Hence several trial pits have to be made before you begin regular trenching. If you find the débris, or bed of drift vein-matter thin, you judge you are too far from the mother lode, too far south; and you move up north, and sink again.

The difficulties encountered in this kind of work are very great, involving much time and expense, especially if the soil is deep and the water quick. The aid of steam pumps is often necessary. The final results are often disappointing, entailing great loss; but should you happen to find a rich lode, the joy and elation caused by the event are indescribable. It is no less a thing than the discovery of great wealth to enrich and benefit a nation.

The intelligent explorer, aside from the glory which attends his successful efforts, finds not only, as Shakspeare says, "sermons in stones," but much that interests him generally, in nature's wondrous ways. His attention is arrested by the varying structure and quality of the underlying rocks, which form the back-bone of Keweenaw Peninsula. The deposition of various minerals, in veins or lodes, by electrical currents, affords evidence of a powerful agent working silently and unseen. Some other powerful agent has disturbed the whole formation in a powerful way, rending it asunder, and tilting it up.

Then his superficial explorations afford more food for thought. The drift and soil covered with old forests has many utter-

ances of the past. It claims parentage of the glacier — cold, hard, crushing, grinding parent indeed, yet still not without beneficence.

The pulverized rock, ground to silt, clay, sand, and gravel, is spread over the barren, stony plains, inviting the growth of moss, shrub, plant, and in time the mighty pine, with its graceful bird's-eye maple associate. But while this deposition is taking place, the bedded rocks of the country are not only rasped off and smoothed by the ice planer, which is shod with feet and points of hard green-stone and granite, scoring and grooving the softer amygdaloids imperceptibly, but leave indelible traces of their work for our instruction and guidance. For the score marks often lead to practical results; they are the keys, so to speak, which unlock hidden treasures.

Many examples might be given to illustrate the line of movement and force of glaciers. The writer will offer one. Ranging the woods and becoming tired, our explorer sat down upon a moss-grown bowlder, took out his restful pipe, and began to smoke. Casually he tapped the bowlder with his pick. The metallic ring it gave out startled him. He speedily tore off the accumulated moss of ages, and, lo! a great mass of solid copper met his astonished gaze. This mass, when finally cut up, weighed eighteen tons, and was worth $10,000. It was smooth on all sides but one: that side was serrated, as though the mass had been torn violently from its matrix and with great force, for the mass was two feet in thickness. Will any one venture to calculate the tremendous power that broke in two this tenacious lump of copper? Examination showed the fact that the outlines of the mass, smooth and hammered, had not been shaped by the glacier, hence it was decided that this interesting and gigantic "float" had not traveled far, and that the vein it was torn from was not distant. The smooth appearance of the copper bowlder was attributed to the work of the "ancient miner." And, just here, you are introduced to a very old explorer, — no one knows how old, — but one of the most useful and skillful men that the modern explorer has any knowledge of; one he is glad to associate with fraternally, but only through his works.

Now the discovery of this great mass of copper doubtless caused our "ancient miner," or explorer, to leap with joy, as it did us. But his extreme elation did not last. He soon found out, to use

a modern phrase, that he had an elephant on his hands. The treasure was too large and solid. But he did the best he knew how with his stone and copper tools, knocking off all projections. In vain he tried fire to soften and reduce the mass. He doubtless secured many small pieces, but was obliged, finally, to leave the major part of the copper. We can fancy that he felt blue as he took up his line of march to his canoes, leaving so much wealth behind. Human nature is ever the same. But he left numerous stone hammers, copper chisels, and much charcoal about the mass, to attest his work.

Leaving the big mass for a while where it was found, to be gazed at by thronging visitors, the explorer went about to find whence it came. It lay upon a rocky ridge where the glacier dropped it. Our explorer set his men to work trenching some 50 feet to the north and east of the mass. Within a few days the mother vein was found, and so truly, that after uncovering it, the very spot where the mass had been torn from, was struck. Sticking up in the vein, a mass of copper was exposed with upper edges rough and jagged. By actual measurements, it was found that the "float" mass would just fit to the one in place.

A mine was opened on this vein, but like many another, it disappointed expectations. The copper, *in place*, was blown out by a "sand blast," and *that* seemed to be all there was of it. The mine was a failure.

The float mass was cut into pieces convenient for handling. A steel chisel with a long shank was used. Two men, with heavy steel hammers, struck the chisel. The groove cut was about one inch wide. The process of cutting was slow and laborious.

One word about these "ancient miners," so called for want of a better name. Everywhere throughout the copper districts, including Isle Royale, on the north shore of Lake Superior, they have left numerous evidences of gigantic operations, as well as of much skill. Their stone hammers, also other rude implements, are found wherever there are copper veins. So far as the writer knows, no great successful mine has ever been opened in the Lake Superior region, that did not show on the surface, the work of the unknown man. Many striking examples might be adduced, but the limits of this paper forbid. Their sagacity in finding lodes, or veins, is what astonishes the modern explorer more than anything else in these wonderful people. There may or may not have been heavy

forests covering the copper ranges at the period or periods of their visits, but it is certain that the same drift matter that now overlies the bed-rock existed in his day; for all his work, shallow or deep, is found in the drift sometimes to the depth of 50 feet or more. But he had no steel tools or powder; his work was performed with wooden shovels, birch-bark baskets, stone hammers, and rude copper chisels. Fire and water were his agents also. He likewise used wooden wedges and wooden levers, or pries.

These remains found in ancient pits, covered with leaves and sand and large growing trees, prove that there was timber growing in the district in his day, but to what extent we cannot tell.

Perhaps it is idle to speculate as to what race these prehistoric people belonged. The aborigines of the country knew nothing about mining for copper, or its use. Indeed, they were very superstitious in regard to copper, and always refused to reveal any veins that they professed to know of.

But these prehistoric races may have been of the same kin as the Chippeway. They may have resided in a milder climate, on the borders of the Ohio and Mississippi, and been a pastoral people. Who knows? Stanley finds in Africa cave dwellers, tree dwellers, and lake or river dwellers. He finds men of the stone age, bronze age, and iron age, all living in the same period and country.

Down in New Mexico and Arizona, we find to-day savage Apaches, without home or dwelling place; we find mound builders in pueblos, cave dwellers, pastoral people with flocks and herds, wheat and cotton growers, spinners and weavers of cotton and wool, all essentially alike, all Indians.

But we are wandering from our subject.

Our copper explorer, after he has found a workable vein, turns it over to the regular miner, and his work may be said to be done. But he seeks new fields. Notwithstanding so much has been done, more remains to be done. Such is the extent of the copper districts, and so great are the difficulties to be overcome in explorations, that it may truthfully be said that very little is yet known of the vein phenomena of the lake region. All that has been done, important as it is, might be termed mere scratching of the surface. It remains for the future to unfold other hidden treasures of that great and wealthy section of our State. Generations hence there will be new "finds," new disclosures. As the present working

mines become impoverished, or should a greater demand for that useful metal, copper, spring up, explorers will be stimulated to new exertions, almost sure to be crowned with success.

Accident often plays an important part in discovery. At any time some wood-chopper or partridge hunter may stumble over a mass of copper in the woods, and a great lode be revealed that will enrich the world.

The possibilities of the Lake Superior country are not within calculation. JOHN H. FORSTER.

EASEMENT CURVES.

A RAILROAD track, as usually located, consists of a succession of tangents and circular curves. When a train, moving rapidly along such a track, passes from a tangent to a curve, or the reverse, it receives a shock of greater or less severity in proportion to the sharpness of the curvature. This shock is the cause of discomfort to passengers, of danger of derailment, and of injurious wear and tear of rolling stock and track. Both good policy and true economy dictate that these evils should be remedied as far as possible, by the removal of their cause, if it can be done without too great cost. Especially is this the case when the desired result can be obtained without any additional cost except that of a very small amount of labor on the part of the locating engineer.

Since the cause of the shock is evidently the inability of the moving train to adapt itself instantaneously to an abrupt change of direction, the remedy must just as evidently be sought in such a modification of the alignment of the track as will enable this change of direction to be made gradually.

The only satisfactory solution of this problem is obtained by introducing between the tangent and the curve, another curve of greater radius and easier curvature. Such a curve is called a "transition," or "easement," or "taper" curve, or "curve of adjustment."

Both the evil and the remedy have long been known to intelligent engineers, but it must be confessed, to the discredit of the profession, that the application of the remedy was, until quite

recently, left almost universally to the wisdom of the track foreman, and is still largely so left. This gentleman proceeds, with no guide but his judgment, to throw the track inward opposite the original point of curvature, extend the curve backward along the tangent, as far as he thinks proper, and then connect it with the original curve as best he can by eye.

This, of necessity, introduces a short piece of curvature sharper than the original, and is a very crude, unscientific, and unsatisfactory operation; but it is the best that can be done so long as it is postponed until after the track is graded. To be correct and effectual, the remedy must be applied before the grading is commenced, since it involves a modification of the alignment of the entire curve, and therefore falls within the duty of the locating engineer.

Of late years the importance of this subject has become generally acknowledged by the engineering profession, and many of its members are applying more or less correct scientific principles to its treatment. There are still very many, however, who entirely ignore it, and, as the writer believes, very largely for the reason that the transition curve has been usually shrouded in so much mathematical mystery that engineers who are not expert mathematicians have been discouraged from attempting to use it. If the writer can succeed in brushing away a part of this mystery, and in showing that any man who is mathematician enough to lay out a circular curve, can also lay out transition curves with almost equal ease, and thus aid in bringing about their more general adoption, the object of this paper will be accomplished. A brief preliminary study of the principles involved and the methods generally employed, will be useful.

Let us suppose a tangent $A\ B$ and a circular curve $B\ C$ to be located in the usual manner, B being the $P\ C$, or point of curvature.

Since from the requirements of the case any true easement curve should have a larger radius than that of the curve with which it is to connect, it follows evidently that no such curve can be introduced between the given tangent and curve which will be tangent to both of them, without moving either the main curve or the tangent a certain distance inward toward the center of the curve. In practice it is usually the curve which is so moved, and the amount of movement is called the "shift of the curve," which

we will designate by S. It is for this reason that easement curves should always be introduced before the grading is done.

There are several different forms of easement curves in use in this country, which may be classified under three heads.

1. A single simple circular curve of larger radius than that of the main curve.

This form is advocated by so high an authority as W. H. Brown, Esq., Chief Engineer of the Pennsylvania Railroad, and perhaps by others, but does not appear to be very extensively used. It is certainly very much better than nothing, and may in many cases be sufficient; but it is not the best either in theory or practice. In using this form, we may either leave the original $P\ C$ unchanged and shorten the radius of the central curve, or the starting point of the easement curve, which we will call the $P\ T\ C$, may be moved back along the tangent to some point A, and the radius of the central curve remain unchanged. In the first case, the formulas given by Henck (Sec. 81) may be employed: —

Let I = the central angle of the original curve
R = the radius " " " "
D = the degree of curvature " " " "
R_1 = the assumed radius of the easement curve (which must be greater than R), D_1 = its degree of curvature, and n_1 its length in stations of 100 feet. R_2 = the radius, D_2 = the degree of curvature, and n_2 = the length of the new central curve Then —

$$R_1 - R_2 = \frac{(R_1 - R) \operatorname{Sin} \frac{1}{2} I}{\operatorname{Sin} (\frac{1}{2} I - n_1 D_1)} \tag{1}$$

$$n_2 = \frac{I - 2 n_1 D_1}{D_2} \tag{2}$$

In the second case, the following approximate formulas for the value of S may be convenient: —

$$S = \tfrac{7}{8} n_1^2 \left(D_1 - \tfrac{D}{4}\right) \tag{3}$$

If $D_1 = \frac{D}{2}$, which theory would indicate to be its best value, this formula becomes —

$$S = \tfrac{7}{32} n_1^2 D \tag{4}$$

If in addition we make $n_1 = 2$, which will hereafter be shown to be a very convenient value,

$$S = \tfrac{7}{8} D \tag{5}$$

2. A compound curve made up of several arcs having chords of equal lengths, and of regularly increasing degrees of curvature.

Easement curves of this form are usually called "taper curves," and are in much more general use than the preceding form. Engineers who use them differ considerably in the methods which they employ in setting them out, and in the values which they give to the lengths and deflection angles of the equal chords.

Wm. Hood, C. E., uses chords 30 feet long (or one rail length), and employs three different tapers, according to the degree of curvature of the central curve. The first changes 0° 30′ to each 30 feet, the second 1° to each 30 feet, and the third 2° 30′ to each 30 feet. The curve is set out by deflection angles, with a transit. The formulas and tables for this method may be found in "Engineering News," Vol. XX, pp. 42 and 60.

The method employed by Willard Beahan, C. E., is similar to Hood's, but uses chords 50 feet in length. The curve is set out by deflection angles. His formulas and tables may be found in "Railroad Gazette," Vol. XXI, page 352.

A. L. Mills, C. E., uses successive arcs of 1°, 2°, 3°, etc., curve, but varies the length of the equal chords according to the degree of curvature of the central curve, from 100 feet for a 3° 30′ curve, or less, to 30 feet for a 6° 31′ curve or more. The curve is set out by offsets from the tangent. His formulas and tables may be found in "Engineering News," Vol. XX, page 133.

A. M. Wellington, C. E., in the "Railroad Gazette," Vol. XIII, page 143, gives a method which is similar to that of Mr. Mills, in the use of offsets in setting out the curve, but employs chords of either 50 or 25 feet, and degrees of curvature changing either 0° 30′ to 50 feet, 1° to 50 feet, or 1° to 25 feet. He gives full rules and tables of offsets for the use of this method in the article referred to. Under this head will also come the methods given in some of our engineering field books for substituting a five-centered curve for a single circular curve.

Curves of this form do not meet precisely the theoretical requirements of the case, but when the chords used are not too long and the changes of curvature not too abrupt, the approximation is sufficiently close for all practical purposes. They are all, however, subject to the serious objection that they require the use of somewhat complicated formulas, and either elaborate tables of offsets or deflections, or frequent movements of the transit at the expense of considerable loss of time. If the locating engineer happens to find himself in the field without these formulas or tables, he will be

completely at sea, unless he is a sufficiently expert mathematician to calculate them for himself on the spur of the moment, with great liability to error. For this reason, this form of curve is not to be recommended for general use.

3. The third form of easement curve is what is commonly called a "spiral," and is a curve whose radius commencing with infinity at the junction of the curve with the tangent (*P T C*), gradually diminishes until at the junction with the central curve (*P C C*) it is equal to the radius of that curve. A curve of this form meets exactly the theoretical requirements of a transition curve. It also meets in the best possible manner another practical want.

When a train is moving on a curved track, the centrifugal force causes a constant tendency to mount the rail and leave the track on the outer side. This tendency is overcome in practice by elevating the outer rail sufficiently to counteract the centrifugal force by creating an equal tendency to slide inward under the action of gravity. The centrifugal force, and consequently the elevation of the rail, is proportional to the degree of curvature, and where a track is formed as usual, of a tangent and single circular curve, theory requires that at the point of curvature the outer rail should have the *full elevation* due to the *curve*, and at the same time *no* elevation at all for the tangent. This of course is impossible, and in practice the elevation is run out along the tangent at the rate of about 50 feet for each inch of elevation. This practice introduces elevation where it is not needed, and is an evil only less than the one it is intended to remedy, and therefore ought, if possible, to be avoided. This is done in the most perfect manner by introducing a transition curve in which the elevation, beginning at *O* at one end of the curve, increases uniformly until at the other end it is equal to the full amount due to the central curve, and the radius of which is at every point exactly proportional to the elevation. Any form of easement curve meets both of these requirements approximately to a greater or less degree, but the spiral is superior to all others in this respect, and for this reason its universal use is to be recommended, provided the difficulties which have discouraged its use can be removed.

The form of spiral most commonly used and most nearly conforming to the theoretical requirements of our problem, is the cubical parabola. It would take up too much space in this paper

to enter upon the study of this curve and of the various methods employed for laying it out on the ground. Those who may wish to do so will find very interesting discussions in the "Railroad Gazette," Vol. XXI, pages 1 and 93, and Vol. XII, page 639; in "Engineering News," Vol. VIII, pages 214 and 246, and "Clemens's Railroad Engineer's Practice," and also a very similar curve called Froude's curve of adjustment in that well of engineering learning, "Rankine's Civil Engineering." In "Engineering News," Vol. XXIII, Mr. A. M. Wellington entered upon a discussion of the subject which, if completed, might have made this paper unnecessary, but unfortunately, he stopped short before reaching the practical application of his ideas.

It will be sufficient for our purpose to take the three following equations, which express the properties of the curve: —

$$Y = \frac{X^3}{6lR} \tag{6}$$

$$O = \frac{l^2}{6R} \tag{7}$$

$$S = \frac{l^2}{24R} \tag{8}$$

In these equations, X is the abscissa and Y the ordinate of any point on the transition curve, the abscisses being measured from the $P.T.C.$, or origin of the curve, along the tangent produced, and the ordinates measured from the tangent and at right angles to it; O is the ordinate of the terminal point, or $P.C.C.$ of the curve, l is the length of the curve, and R is the radius, and S the shift of the central curve.

We also have the following equation expressing the theoretical relations between the length of the transition curve and the elevation of the outer rail and the slope which it is necessary to give to this rail to reach this elevation: —

$$l = ei \tag{9}$$

In this equation, e = elevation in feet, i = the distance in which the rail rises one foot. Another property of the curve which we must use, is that half the length of the curve must lie on each side of what would be the $P.C.$ of the circular curve, if there were no transition curve.

If we make D = the degree of curvature of the central curve, then we have —

$$R = \frac{5730}{D} \tag{10}$$

From equation (9), it appears that theoretically l is proportional to e and i, and since in practice and theory e is made proportional to D (within certain limits), l should vary with D. The attempt to conform to this condition, is the cause of nearly all of the difficulty that is met with in the use of the cubic parabola. It may be almost entirely avoided by giving a *constant* value to l.

This will have no effect upon the accuracy of the curve, for formulas (6), (7), and (8) will remain unchanged, and the curve will still be a perfect cubic parabola with varying proportions. Formula (9) is not a fundamental one, but is necessary only to adapt the curve to meet the requirements of an *extreme case*. Hence if we adopt a value of l, which is the proper one for *extreme* values of e and i, the same value may be used for all *other* values of e and i, with no other effect than that the resulting transition curve will be easier than in the extreme case, which cannot be considered a fault.

For the extreme or maximum value of e, few if any railroads in this country use a greater elevation than 8 inches or $\frac{2}{3}$ foot. For the extreme or minimum value of i, Froude (quoted by Rankine with apparent approval) recommends 300 feet, or 1 inch rise in 25 feet. Substituting these values in equation (9), we have —

$$l = 200 \text{ feet.} \qquad (11)$$

The engineers of the Pittsburgh, Cincinnati, and St. Louis Railroad are said to use a value of $i = 720$, or 1 inch rise in 60 feet, which would make $l = 480$ feet. This would of course make an easier transition curve; but in a country where it is necessary to use curves so sharp as to require the maximum elevation (which, according to the latest practice of 1 inch elevation to each degree of curvature, would be 8° or more), it would often be impossible to find room for the two adjoining transition curves of so great length, while it would very seldom occur that a length of 200 feet could not be obtained, and the much greater simplicity of the field work makes it a very convenient length.

To find the $P.T.C.$ or starting point of the transition curve, we first find the intersection of the tangents and the angle of intersection ($= I$) in the usual way; then since half the length of the curve must lie on each side of the original $P.C.$, we find the apex distance of the $P.C.$ for the proposed $D°$ central curve, and the angle I, either by the formula $T = R \cdot \text{tang.} \frac{1}{2} I$, or by the tables of apex distances, which are now to be found in all modern field

books, and add $\frac{l}{2}$ l–$\frac{1}{2}$ l = 100 feet. The sum will be the apex distance of the $P\ T\ C$.

If in equation (8) we substitute for R its value, $\frac{5730}{D}$, and for l its value, 200, we have —

$$S = 0.291 \times D \qquad (12)$$

This is the distance which the central curve is to be thrown inward toward the center. If the line has already been located in the usual manner, and it is desired to substitute a transition curve before setting the slope stakes, this can be done without the use of a transit, by simply moving the central stakes inward a distance equal to S, and for this purpose it will be sufficiently accurate to call $S = 0.3\ D$, a value very easily remembered. If a locating engineer is very much hurried, or is not perfectly familiar with the setting out of transition curves, it might be advisable to make the location in the usual manner, and leave the revision to some leisure moment. This is another point in which this is the most convenient form of transition curve.

By making the same substitutions in equation (7), we obtain for the ordinate, or offset from the tangent, of the $P\ C\ C$ —

$$O = 1.164 \times D. \qquad (13)$$

This is evidently equal to $4S$.

From equation (6) we observe that the offsets, or ordinates at intermediate points on the curve, are proportional to the cubes of the abscisses or distances of the points from the $P\ T\ C$ measured along the tangent. Making these distances (or x in the formula) successively $\frac{1}{8}l$, $\frac{2}{8}l$, $\frac{3}{8}l$, $\frac{4}{8}l$, $\frac{5}{8}l$, $\frac{6}{8}l$, $\frac{7}{8}l$, and l, which gives points at intervals of 25 feet, we have for the successive values of the offsets,

$\frac{1}{512}O$, $\frac{8}{512}O$, $\frac{27}{512}O$, $\frac{64}{512}O$, $\frac{125}{512}O$, $\frac{216}{512}O$, $\frac{343}{512}O$, and O:

or, .00227D, .018D, .061D, .145D, .284D, .491D, .779D, and 1.164D.

The transition curve may be set out by means of these offsets, and for this reason it would be well for the engineer to keep in his note-book a table of the above values of y, though the manner in which they are obtained is so plain that with a very little practice they can be easily calculated in the field if necessary.

This, however, is not a very convenient method of setting out the curve, though it may be useful for setting over the stakes of that portion of a line located in the usual manner, which lies opposite the transition curve. For this purpose the following table may be convenient: —

TABLE I.

Distance of point from $P\ T\ C.$	Offset.		
	Tangent to transition curve.	Tangent to original line.	Original line to transition curve.
25 feet	$.00227 \times D$	0.0	$0.00227 \times D$
50 "	$.018 \times D$	0.0	$0.018 \times D$
75 "	$.061 \times D$	0.0	$0.061 \times D$
100 " $= P\ C$	$.145 \times D$	0.0	$0.145 \times D$
125 "	$.284 \times D$	$0.054 \times D$	$0.230 \times D$
150 "	$.491 \times D$	$0.218 \times D$	$0.273 \times D$
175 "	$.779 \times D$	$0.491 \times D$	$0.288 \times D$
200 "	$1.164 \times D$	$0.873 \times D$	$0.291 \times D$

Column 2 contains the offsets from the tangent to the transition curve, as given above; column 3, the offsets from the tangent to the original curve calculated by the formula $O = \frac{1}{8}n^2D$, in which O is the offset, and n the distance from the $P\ C$ in stations of 100 feet; and column 4, the differences between these offsets, or the distance from the original line to the transition curve. In case of necessity, this table can be easily calculated in the field.

A much simpler and better method of setting out this curve, is by deflection angles with the transit. It is true that if the distances are measured along the curve by chords, as would naturally be done, the curve ceases to be a cubic parabola, and becomes what Rankine calls Froude's curve of adjustment; but within all ordinary limits of railroad practice, the two curves are so nearly identical that they may be regarded as such without sensible error.

Supposing the transit to be setting at the $P\ T\ C$, and calling the deflection angle from the tangent to any point of the curve, a, we have evidently —

$$\text{Tang. } a = \frac{y}{x} = \frac{x^3}{6lR} \div x = \frac{x^2}{6lR} = \frac{x^2D}{34380 \times l} \qquad (14)$$

From this equation it appears that tangent a varies as x^2 and D. Since within all ordinary limits of the value of D an angle varies very nearly as its tangent, we may say without material error that for all practical purposes the angle of deflection from the $P\ T\ C$ to any point on the transition curve will vary directly as the degree of curvature of the central curve, and as the square of the distance of the point from the $P\ T\ C$. Hence if we have the value of a for the terminal point of the curve (or the $P\ C\ C$), for $D = 1°$, all other

values can be calculated with perfect ease in the field, or tabulated if preferred.

For this terminal point we have from equation (14), since $x = l$, $D = 1$, and $l = 200$.

$$\text{Tang. } a = \frac{x^2 D}{34{,}380 l} = 0.005817. \tag{15}$$

$$a = 0° 20' = \tfrac{1}{3} D°. \tag{16}$$

This is a very simple and easily remembered expression. We can now readily obtain the following values of a for points along the curve at intervals of 25 feet: —

TABLE II.

Distance from P T C.	*Deflection angle.*
25 feet	$\frac{1}{192} D°$.
50 "	$\frac{4}{192} D° = \frac{1}{48} D° = 1\frac{1}{4}' \times D$.
75 "	$\frac{9}{192} D° = \frac{3}{64} D°$.
100 "	$\frac{16}{192} D° = \frac{1}{12} D° = 5' \times D$.
125 "	$\frac{25}{192} D°$.
150 "	$\frac{36}{192} D° = \frac{3}{16} D° = 11\frac{1}{4}' \times D$.
175 "	$\frac{49}{192} D°$.
200 feet = *P C C*	$\frac{64}{192} D° = \frac{1}{3} D° = 20' \times D$.

Since the transition curve takes the place of 100 feet of tangent and 100 feet of curve on the original line, it is evident that the total central angle of the curve $= D°$. Hence after the *P C C* has been set, if we set the transit over it, take a backsight to the *P T C* and deflect $D° - \frac{1}{3} D° = \frac{2}{3} D°$, we will have the new tangent, from which the central curve can then be set out in the usual manner. If after deflecting from the *P T C* $\frac{1}{3} D°$ to set the *P C C*, we leave the vernier clamped, and take the backsight at the *P C C* with the vernier still reading $\frac{1}{3} D°$, we have only to deflect till it reads $D°$ to get the new tangent.

If, as may sometimes happen, the *P T C* should be inaccessible, we may set up at the original *P C* 100 feet farther forward on the tangent. Then since the abscissa of the *P C C*, when measured from this point, is half as great as when measured from the *P T C*, while the ordinate is the same, it is evident that the tangent of the deflection angle to the *P C C* or (within ordinary limits) the angle itself, will be twice as great as when taken at the *P T C*. Hence deflect $\frac{2}{3} D°$ from the tangent, measure 100 feet, and set the *P C C*. Set up at this point, backsight to the *P C*, and deflect $\frac{1}{3} D°$, which will give the new tangent. The transition curve can then be set in backward. After setting out the central curve and reaching the *P C C* at the other end, the second transition curve is to be set out

from that point. The process is the reverse of the one just described, and the following table gives the deflections from the tangent to the central curve at this point to points on the transition curve 25 feet apart: —

TABLE III.

Distances from P C C.	*Deflection angle.*
25 feet	$\frac{2.3}{16.2} D°$.
50 "	$\frac{4.6}{16.2} D° = \frac{1}{4}\frac{1}{4} D° = 13\frac{3}{4}' \times D.$
75 "	$\frac{6.9}{16.2} D° = \frac{2}{6}\frac{1}{4} D°.$
100 "	$\frac{8.0}{16.2} D° = \frac{5}{12} D° = 25' \times D.$
125 "	$\frac{9.5}{16.2} D° = \frac{1}{2} D°$ n'rly $= 30' \times D.$
150 "	$\frac{10.5}{16.2} D° = \frac{9}{16} D° = 33\frac{3}{4}' \times D.$
175 "	$\frac{11.6}{16.2} D° = 37' \times D.$
200 feet $= P\ T\ C$	$\frac{12.5}{16.2} D° = \frac{2}{3} D° = 40' \times D.$

As this table is not readily calculated or remembered, except the deflections to the 100 and 200 foot points, it will be most convenient to set out only these two points from the *P C C*, and any other necessary points can then be set in from the second *P T C*.

If the *P T C* is inaccessible, set out from the *P C C* as much of the transition curve as is practicable, then deflect from the tangent to the central curve $\frac{1}{3} D°$, measure 100 feet, and set the *P C*. Set up at this point, backsight to the *P C C*, and deflect $\frac{2}{3} D°$, and the transit will then point along the tangent to the transition curve 100 feet back from the *P T C*.

In setting centers for track laying, it is well to put them 25 feet apart, but on location it will usually be sufficient to set them 100 feet apart. The whole process then becomes exceedingly simple, and it is only necessary to observe the following rules without any special tables at all: —

1. Find the apex and the intersection angle *(I)* and the apex distance *(T)* for the proposed *D°* curve in the usual manner. Then $T + 100$ will be the apex distance of the *P T C*.

2. Set transit at the *P T C*, and deflect from the tangent $\frac{1}{12} D°$ for the first chord of 100 feet, and $\frac{1}{3} D°$ for the second. This fixes the *P C C*.

3. Set at the *P C C*, backsight to the *P T C*, and deflect $\frac{2}{3} D°$. This gives the tangent to the central curve.

4. Set out the central circular curve in the usual manner, making its angular length equal to $I - 2\ D°$.

5. At the end of the central curve (which is the second *P C C*), deflect from the tangent $\frac{5}{12} D°$ for the first 100 foot chord and $\frac{2}{3} D°$ for the second. This fixes the second *P T C*.

6. Set at the $P\ T\ C$, backsight to the $P\ C\ C$, and deflect $\frac{1}{3}\ D°$. This gives the tangent.

If the line has been located in the usual manner, and it is desired to fit in transition curves without changing the tangents, it will be best to set out the two transition curves first, and then fit in the central curve between them. The unavoidable small discrepancies of linear and angular measurement will then be thrown upon the central curve, where they will do the least harm.

If, as will often be the case, the $P\ T\ C$ should come between regular stations on the located line, the proper deflections to such regular stations as may come on the transition curve may be calculated, if desired, by formula (14), but it will be much more convenient to leave out the stations, and set the stakes at regular distances from the $P\ T\ C$. The regular stationing can be resumed on the central curve.

Lines set out by this method can, on account of its simplicity and uniformity, be retraced with as much ease and accuracy as an ordinary circular curve, which could hardly be said with perfect truth of any other method.

This method of setting out transition curves was worked out by the writer for his own use, and, so far as he is aware, it has never before been published, though on this point he may possibly be in error. It was the result of a long effort to find some method which would be sufficiently accurate for practical use, and at the same time free from the intricate and troublesome formulas and tables which make all other methods forbidding, and one which the average transit man could use without being tempted to violate the third commandment. Like many other methods in use among engineers, it is only approximately correct; but the error is so small as to be practicably inappreciable, and the writer has found it so entirely satisfactory in his own practice, which includes much sharp curvature, that he now uses it constantly for all curves exceeding 2°.

Engineers who are expert mathematicians, and have the desire and leisure to make their work theoretically perfect, will probably prefer some other method; but to the younger and less expert members of the profession, and perhaps to others who are pressed for time, it is hoped that the extreme simplicity of this method may make it of some value.

E. W. Muenscher, *Chief Engineer, M. & G. R. R. R.*

THAT PROBLEM IN LAND SURVEYING.

SOMETIME in 1889, I received from G. A. Randall, of Oshkosh, Wis., a request to give him a method for retracing a meander line of the United States Survey, consisting of several courses between two meander posts. It was a problem which, in a general way, I had met with a great many times in my practice; and I sat down, without hesitation, to write a solution. Before I was half done, it dawned upon me that my practice hitherto had been all wrong. I also realized that no text book in my possession so much as hinted that there was any such problem.

I worked out a solution, and sent it to the gentleman; but it was by no means the best solution, as I found on further investigation. Last winter I presented the problem in another form to this Society, and published it in the "Annual," with a request for solutions. I was then contemplating the issue of a revised edition of the "Manual of Land Surveying," and I wanted to get the best possible solution for use in the "Manual." I regret to say that I did not get any correct solutions, from any source, in time to make use of them in the "Manual:" and while it contains the problem and its solution, that solution is not by any means, in my opinion, the best. In my search for solutions from others, I presented the problem to several surveyors of my acquaintance, who in my judgment were the best qualified to give good ones. None of them succeeded until they had given it two or more trials. One of them who rides mathematics for his hobby, failed twice, and then told me that it could not be solved in the form in which I had given it. Then he went at it and worked out a first-class correct solution. He has been worrying and tearing that problem ever since, cuffing it this way and that, and dissecting it, until it does not seem possible there can be anything in its anatomy that he is not familiar with. He has sent me between 50 and 100 solutions, and has more left.

In the meantime, I had sent it to several of the engineering journals. The *News* at first refused to publish it, on the grounds

that it was a poorly concealed advertisement of the "Manual," and that it was not intricate enough for their columns, any way. So I made an advertisement of it in the *News*. Something over fifty persons responded to the publication in these journals, of whom only nine sent correct solutions. Among those who failed were a professor of civil engineering in a State university, a lieutenant of engineers in the United States army, the senior assistant engineer of an Eastern railroad, and a very prominent Canadian engineer and surveyor. All this is mentioned simply as showing the grounds for my belief that the correct solution of this problem by surveyors is the exception rather than the rule. Where land is very valuable, as it is in a great many cases where the solution is called for in locating boundaries, it is highly important that the solution should be a correct one. I submit four solutions by different parties, and will add that the easiest and shortest one I know of is a graphical solution suggested by H. C. Pearsons, who, if present, will readily demonstrate it.

SOLUTION No. 1, BY F. HODGMAN.

PROBLEM: *To correct a random traverse of several courses between two known points.*

To solve the problem, we need a convenient basis of comparison between the courses and distances of the true line and those of the random. This will best be found by calculating the courses and distances of lines which will join the starting and closing points of the two surveys, calculating both as they would be according to the meridian and the measure of the random. It is better to calculate these in terms of the random, because of the greater convenience to the surveyor in applying his corrections in the field.

Preliminary Propositions: 1. A difference in length of the chains on different surveys by the same notes from a common starting-point, causes a difference in the length of the respective courses, without changing their direction. Hence, the closing points of the several surveys will all lie in one straight line with the common starting-point, and the relative length of the several chains is shown by the distances of the closing points from the common starting-point.

2. The effect of using different meridians (or variation of the needle) in such a case, is to swing the lines around the starting-point as a center, without changing the lengths of the courses, or

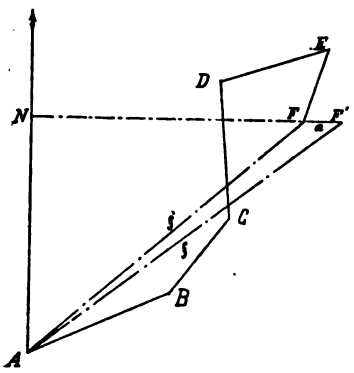
their angles with each other. Hence if chains are of equal length, the termini of the surveys will all lie in one arc, having the common starting-point for their center.

3. Hence the position of the terminus of a random, with relation to such a line and arc, passing through the terminus of the true line, determines both the difference in length of chains and of the meridians of the two surveys.

Let A, B, C, D, E, F, represent a true line of several courses, and F' the terminus of a random run from A to retrace the line, the course and distance of the line $F\,F'$ being known.

From A draw $A\,F$ and $A\,F'$.

The angle $F\,A\,F'$ measures the difference in courses, or, in other words, the correction for variation of the needle.



The length of the lines $A\,F$ and $A\,F'$ measures the comparative length of the chains used on the two surveys. $\frac{A\,F}{A\,F'}$ is the length of the chain used on the true line in terms of the chain used on the random.

The course of any part of the broken line, as $A\,B$ (in terms of the random) is equal to the bearing, by the original notes $\mp$ the angle $F\,A\,F'$.

The length of any course, as $A\,B$ in terms of the random, is equal to the length given in the original notes $\times \frac{A\,F}{A\,F'}$.

To find the correction to be applied to the stakes in the angles of the random, first compute the total latitude and departure of each of the points in the random line.

Second, convert the notes of the true line into terms of the random by changing the bearings and lengths of the several courses, and giving them as they would be according to the meridian and chain of the random, and compute the total latitudes and departures of the several points.

A comparison of the two results will give the correction to be applied at each stake of the random.

Example: A highway between nearest known points is described as follows: N. 62° E., 14 chains; N. 43½° E., 8 chains; N. 5° W., 12 chains; N. 72½° E., 10.25 chains; S. 12° W., 6.43 chains.

A random run with variation of needle 2° 17′ E. came out 62 links east of the point. Stakes were set at the angles of the random.

1. What is the variation of the needle as referred to the meridian of the original survey of the highway?

2. How much, and in what direction, must the stakes in the angles of the random be moved, to place them in the angles of the original line?

		N.	S.	E.	W.	Total Lat.	Total Dep.
1. N. 62° E.,	14.00	6.57	....	12.36	....	6.57	12.36
2. N. 43½° E.,	8.00	5.80	....	5.51	....	12.37	17.87
3. N. 5° W.,	12.00	11.95	....	....	1.05	24.32	16.82
4. N. 72½° E.,	10.25	3.08	....	9.78	....	27.40	26.60
5. S. 12° W.,	6.43	....	6.29	....	1.34	21.11	25.26

Tan. $F'AN = \frac{NF'}{AN} = \frac{25.26}{21.11} = 1.19663 = \text{tan. } 50°\ 7'$ ∴ $AF'F = 39°\ 53'$.

$AF' = \sqrt{AN^2 + NF^2} = \sqrt{21.11^2 + 25.26^2} = 32.92$. $FF' = .62$.

In the triangle $AF'F$ we now have two sides and the included angle to find the remaining parts. We will call the angles AF and F', and the sides opposite, a f and f'.

$$f + a : f - a : : \text{tan. } \frac{F + A}{2} : \text{tan. } \frac{F - A}{2}.$$

$$32.92 + 62 : 32.92 - 62 : : \text{tan. } \frac{140°\ 07'}{2} : x :$$

or 33.54 : 32.60 : : 2.75621 : 2.65431, whence $x = \text{tan. } 69°\ 21\frac{1}{2}'$.

$$A = 70°\ .03\frac{1}{2}' - 69°\ .21\frac{1}{2}' = 42'.$$

As the random came out east of the true line, the correction 42′ must be added to the assumed 2° 17′, to find the variation of the needle from the meridian of the original survey = 2° 59′ E. This will only need to be used in case the line is to be run over again.

To find f': Sin. A : Sin. F' : : 62 : f'.

.01222 : .64123 : : 62 : 32.446.

The length of the original chain in terms of the chain used in the random =

$$\frac{f}{f'} = \frac{32.446}{32.92} = .9856.$$

We will now apply these corrections to the original notes, reducing them to the meridian and measure of the random, and again compute total latitudes and departures.

	N.	S.	E.	W.	Total Lat.	Total Dep.
1. N. 61° 18′ E., 13.80	6.63	....	12.10	....	6.63	12.10
2. N. 42° 48′ E., 7.88	5.78	....	5.35	....	12.41	17.45
3. N. 5° 42′ W., 11.83	11.77	....	....	1.17	24.18	16.28
4. N. 71° 48′ E., 10.10	3.15	....	9.60	....	27.33	25.88
5. S. 11° 18′ W., 6.34	....	6.22	....	1.24	21.11	24.64

The last course is computed simply as a check to prove the correctness of the work, which it does. We now compare results to find the corrections to be applied to the stakes in the random to place them in the true line.

	B.		C.		D.		E.		F.	
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.
Random Line	6.57	12.36	12.37	17.87	24.32	16.82	27.40	26.60	21.11	25.56
True Line	6.63	12 10	12.41	17.45	24.18	16.28	27.33	25.88	21.11	24.64

Stakes are to be moved as follows: At B, North, .06; West, .26; at C, North, .04; West, .42; at D, South, .14; West, .54; at E, South, .07; West, .72 — at F, West, .62.

If it is desirable to correct the stakes by measuring a single course and distance, we may solve these small right triangles.

Taking the first one at B, $\sqrt{6^2+26^2} = 26.7$. $\frac{26}{6} = 4.333+ =$ tan. 77°; hence the correction is N. 77°, W. 26.7 links. At C it is N. 84° 34′, W. 45½ links. At D, S. 75° 28′, W. 55.6 links. At E, S. 84° 27′, W. 73.3 links.

It will be noticed that in this particular example the angular correction can easily be found by subtracting the angle $N.1\ F$ from $N.1\ F'$.

SOLUTION NO. 2, BY F. A. STEIGER.

The solution is embodied in the following table: —

a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
Station.	Course.	Distance.	Lat.	Dep.	Total Lat.	Total Dep.	$\frac{g}{f}$
Stake *A*.....	N. 62° E.	14.00	+ 6.57	+12.36	+ 6.57	+12.36	1.881
" *B*.....	N. 43½° E.	8.00	+ 5.80	+ 5.51	+12.37	+17.87	1.445
" *C*.....	N. 5° W.	12.00	+11.95	— 1.05	+24.32	+16.82	.692
" *D*.....	N. 72½° E.	10.25	+ 3.08	+ 9.78	+27.40	+26.60	.971
" *E*.....	S. 12° W.	6.43	— 6.29	— 1.34	+21.11	+25.26	1.196
Stone No. 3	West.	.62	0.00	— .62	+21.11	+24.64	1.167

a	*i*	*j*	*k*	*l*
Station.	Courses.	$i +$ Constant angle	$\frac{n}{m} \times \frac{g}{\sin i}$,	$\frac{g}{\sin i}$
Stake *A*.....	N. 62° E.	N. 78°-6′ W.	.26	.....
" *B*.....	N. 55°-19′ E.	N. 84°-47′ W.	.41	.....
" *C*.....	N. 34°-41′ E.	S. 74°-35′ W.	.56	.....
" *D*.....	N. 44°-10′ E.	S. 84°- 4′ W.	.72	.....
" *E*.....	N. 50°- 6′ E.	West.	.62	32.92
Stone No. 3	N. 49°-25′ E.	.....	...	32.46

Columns *a*, *b*, *c*, *d*, *e*, *f*, and *g* need no explanation. In column *h* the total departure of each course is divided by its total latitude, giving the tangent of the angle which a line connecting the extremity of that course and the starting point makes with a north and south line. In column *l* this angle is given, with its proper naming, so that we have the courses of the lines connecting with the starting point. In column *j* we have this course affected by a constant angle. This constant angle is found between the lines connecting the starting point, and stone 3 of the original survey, with stake *E*. The courses given in column *j* are *the courses to be used in shifting the stakes from their positions in the new survey to their positions in the original survey.*

Column *k* gives *the distance that each stake is to be moved.* These distances are proportional to the distances of the stakes from the starting point. In the expression, $\frac{n}{m}\left(\frac{g}{\sin i}\right)$, m is the distance of stake *E* from the starting point (32.92), and n is the error of closing (62 links).

The closing course and distance (west 62 links) are included in the table. The angular difference between the last two courses in column *i*, 41′, is *the required error of variation.*

In column *l* the distances between post 5 and stake *E*, and between post 5 and stone 3 $\left(\frac{g}{\sin i}\right)$ of the last two courses, are given. The difference (46 links) between these distances, when taken in connection with the distance (32.92 chains) from post 5 to stake *E*, gives *the proportional error of measurement.* In this example this error is 1.4 links per chain.

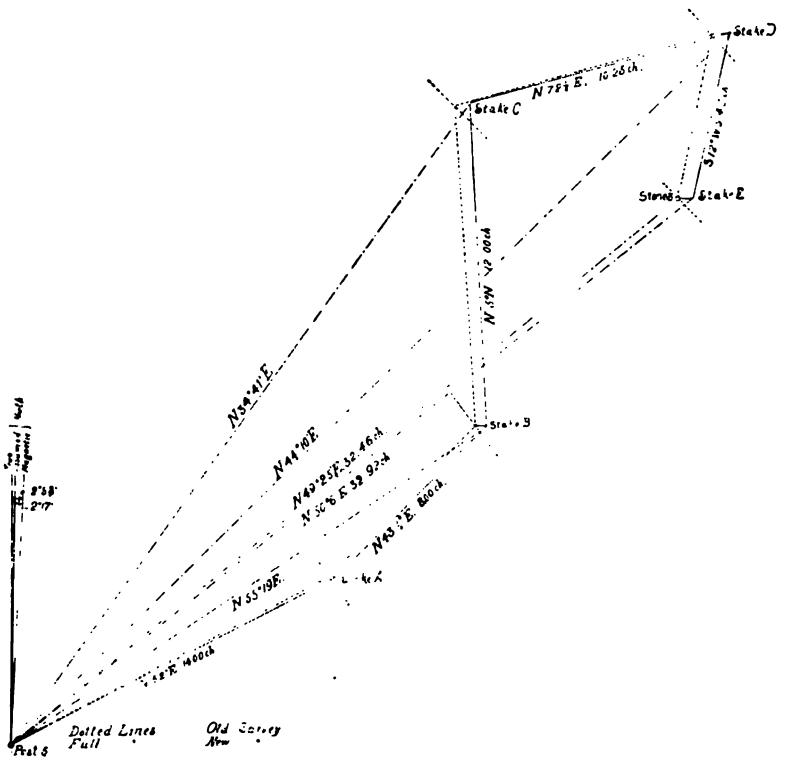
The general problem has three cases: —

1. When the error is all due to a difference in magnetic variation used.

2. When the error is all due to a proportional difference in measurements.

3. When the error is due to differences both in variation and measurements.

If the error were all due to variation, the points of the new survey would fall on arcs of circles passing through the corresponding



points of the old survey, and having the starting point as a common center. The amount of arc included between the old and the new points would measure the error of variation. The chords of these arcs would be proportional to the distances of the points from the starting point, and their lengths could be found when we knew the closing distance, which, in this case, would be a chord of one of the arcs. These chords make constant angles with the lines to the starting point, and their courses can be determined after we have determined the courses of these lines from the total

latitudes, and departures of the points which they connect with the starting point (as in this case).

If the error were all due to a proportional difference of measurements, the points of the new survey would fall on lines connecting the corresponding points of the old survey with the starting point. The distances between the old and new points would be in proportion to the distances of the new points from the starting point, and could be found when we knew the closing distance, which in this case would fall on the line connecting the last station with the starting point.

If the error were due to both a proportional difference of the measurements and a difference of the variation used, the points of the new survey would fall neither on the arcs through the corresponding points of the old survey nor on the lines connecting these points with the starting point.

We have found that the corrections for variation and for measurements are both proportional to the distances of the new points from the starting point — that the directions of the lines correcting the measurements are along the lines connecting the new points with the starting point, and that the directions of the lines correcting the variation are such that they make constant angles with the lines connecting the new points with the starting point.

From these considerations it can easily be seen that the two corrections are proportional to each other — that they make a constant angle with each other — and, therefore, that a line connecting each new point with its corresponding old point will be in proportion to, and make a constant angle with, the lines connecting the new points with the starting point. Although we have three cases, the rule for making the corrections will be the same. Rule:

"Lay off from the new point, lines whose directions are such that they make the same angles with the lines to the starting point, as the closing line does with the line connecting the last station with the starting point, and whose lengths bear the same proportion to the lines to the starting point as the closing distance does to the line from the last station to the starting point."

We get the error of variation and the proportional error of measurements from the difference between the courses and the difference in lengths of the lines connecting the known point of the old survey and the corresponding point of the new survey with the starting point, which is common to both old and new surveys.

In an actual case, the amount of work would be greatly reduced by plotting the survey and scaling the angles and distances.

SOLUTION No. 3, BY S. W. FRESCOLN.

Designate successive corners by No. 5, *A*, *B*, *C*, *D*, No. 3.

Line.	*Bearing.*	*Distance chains.*	
No. 5 — *A*	N 62° E	14.00	
A — *B*	N 43° 30′ E	8.00	Assumed variation
B — *C*	N 5° 00′ W	12.00	= 2° 17′ E
C — *D*	N 72° 30′ E	10.25	
D — No. 3	S 12° 00′ W	6.43	Error of closure. Northings = 0 Eastings = 62 links.

The total error is due to a combination of *error in variation* and *error in chain*.

Let y = error in chain per chain.

Let $10x$ = correction to variation in minutes.

∴ Bearings of random line *differ* from bearings of true line by $10x$ minutes.

A table of nat. sines and cosines gives difference in cos and sin (or lat. and dep.) for each bearing due to a change of 10′; these values multiplied by x and the length of the course will hence produce the errors in lat. and dep. for that course due to the error in variation. In this manner form Table I.

TABLE I.

ERRORS IN LAT. AND DEP. DUE TO ERROR IN VARIATION.

Course	No. 5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—No. 3.
Lat.	—.036x	—.016x	+.002x	—.029x	+.004x
Dep	+.020x	+.017x	+.035x	+.009x	—.019x

Summing — Total error in lat. due to variation ..... = —.075x
" " " dep. " " " ..... = +.062x

Also length of each course multiplied by y and then respectively by cos and sin of bearing will produce the errors in lat. and dep. of each course due to error in chain. Thus form Table II: —

TABLE II.

ERRORS IN LAT. AND DEP. DUE TO ERROR IN CHAIN.

Course	No. 5 — *A*	*A* — *B*	*B* — *C*	*C* — *D*	*D* — No. 3.
Lat.	— 6.58y	— 5.80y	— 11.95y	— 3.08y	+6.29y
Dep	— 12.36y	— 5.50y	+ 1.04y	— 9.78y	+1.34y

Summing —
Total error in lat. due to error in chain..... = —21.12y
" " " dep. " " " " " ..... = —25.26y

Resultant errors = sum of these two, and hence form
(Lat.) the equations : $-.075x - 21.12y = 0$ (1)
(Dep.) $+.062x - 25.26y = .62$ (2)
Solve and find $y = -.014$ (∴ chain is too long.)

$$x = 4.09.$$

∴ $10x = 41$ minutes ; corrected variation = 2° 58′ E.

Substitute values of x and y in tables 1 and 2, which as results are only wanted to nearest link, can in this and in most cases be done mentally, and then by simple addition find corrections for each station, as is clearly shown by following tables: —

TABLE III.

CORRECTIONS IN LINKS PER COURSE DUE TO VARIATION.

Course	5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—3
Lat.	+ 15	+ 7	− 1	+ 11	− 3
Dep.	− 8	− 7	− 15	− 4	+ 8

TABLE IV.

CORRECTIONS IN LINKS PER COURSE DUE TO CHAIN.

Course	5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—3
Lat.	− 6	− 8	− 17	− 4	+ 9
Dep.	− 17	− 8	+ 1	− 14	+ 2

TABLE V.

CORRECTIONS IN LINKS PER COURSE DUE TO BOTH.

Course	5—*A*	*A*—*B*	*B*—*C*	*C*—*D*	*D*—3
Lat.	+ 1	− 1	− 18	+ 7	+ 6
Dep.	− 25	− 15	− 14	− 18	+ 10

TABLE VI.

CORRECTIONS IN LINKS PER STATION ; OBTAINED BY ADDING TO EACH COLUMN OF TABLE 5 THE SUM OF ALL THAT PRECEDES.

Station	*A*	B	*C*	*D*	No. 3
Lat.	+ 6	+ 5	− 13	− 6	0
Dep.	− 25	− 40	− 54	− 72	− 62

If the error in variation were simply desired without wishing the corrections per station, it can be obtained very simply, viz.: by dividing the total error of closure by the total distance, which will be the *sin* of the angular error, near enough for all practical purposes. In fact, it gives 42 minutes instead of 41 minutes, which of course is near enough.

Solution No. 4, by Edward A. Stockwell.

Let α = correction to the length of chain used on random line.

Let Θ = correction to the assumed variation of the needle.

Let x_0 and y_0 = departure and latitude of the true terminal point referred to the starting point as origin.

Let x_1 and y_1 = departure and latitude of the terminal point of the random line referred to the same origin.

Let the bearings be denoted by a, a', a'', a''', etc.

Let the number of chains in the corresponding courses be denoted by n, n', n'', n''', etc.

Then we shall have :

$$(1+\alpha)\, n \sin(a+\Theta) + (1+\alpha)\, n' \sin(a'+\Theta) + (1+\alpha)\, n'' \sin(a''+\Theta) + \text{etc.} = x_0 \tag{1}$$

$$\text{and } (1+\alpha)\, n \cos(a+\Theta) + (1+\alpha)\, n' \cos(a'+\Theta) + (1+\alpha)\, n'' \cos(a''+\Theta) + \text{etc.} = y_0 \tag{2}$$

$$\text{but } \sin(a+\Theta) = \sin a \cos\Theta + \cos a \sin\Theta,$$
$$\text{and } \cos(a+\Theta) = \cos a \cos\Theta - \sin a \sin\Theta.$$

Substituting these values in (1) and (2), and in the results substituting for $\cos\Theta$ the value $1 - 2\sin^2\frac{1}{2}\Theta$, we have —

$$(1+\alpha)[n(\sin a - 2\sin a \sin^2\tfrac{1}{2}\Theta + \cos a \sin\Theta) + n'(\sin a' - 2\sin a' \sin^2\tfrac{1}{2}\Theta + \cos a' \sin\Theta) + \text{etc.} = x_0 \tag{3}$$

$$\text{and } (1+\alpha)[n(\cos a - 2\cos a \sin^2\tfrac{1}{2}\Theta - \sin a \sin\Theta) + n'(\cos a' - 2\cos a \sin^2\tfrac{1}{2}\Theta - \sin a' \sin\Theta) + \text{etc.} = y_0 \tag{4}$$

$$\text{but } n\sin a + n'\sin a' + n''\sin a'' + \text{etc.} = x_1 \tag{5}$$

$$\text{and } n\cos a + n'\cos a' + n''\cos a'' + \text{etc.} = y_1 \tag{6}$$

Substituting these values in (3) and (4), we have —

$$x_1 + \alpha x_1 + \sin\Theta\, y_1 + \alpha \sin\Theta\, y_1 - 2\alpha\sin^2\tfrac{1}{2}\Theta\, x_1 = x_0 \tag{7}$$

$$\text{and } y_1 + \alpha y_1 - \sin\Theta\, x_1 - \alpha\sin\Theta\, x_1 - 2\alpha\sin^2\tfrac{1}{2}\Theta\, y_1 = y_0 \tag{8}$$

Since α and Θ are very small, we may put $\sin\Theta = \Theta$, and $\sin^2\frac{1}{2}\Theta = \frac{1}{4}\Theta^2$, and $\alpha\sin^2\frac{1}{2}\Theta = \alpha\frac{1}{4}\Theta^2 = 0$ by neglecting terms of the third order ; substituting these values in (7) and (8) and reducing, we have —

$$\alpha + \frac{y_1}{x_1}\Theta = \frac{x_0 - x_1}{x_1} - \frac{y_1}{x_1}\alpha\Theta + \tfrac{1}{2}\Theta^2 \tag{9}$$

$$\text{and} \qquad \alpha - \frac{x_1}{y_1}\Theta = \frac{y_0 - y_1}{y_1} + \frac{x_1}{y_1}\alpha\Theta + \tfrac{1}{2}\Theta^2 \tag{10}$$

$$\text{from which} \qquad \Theta = \frac{x_0 y_1 - x_1 y_0}{(x_1^2 + y_1^2)(1+\alpha)} \tag{11}$$

Multiplying (7) and (8) by x_1 and y_1 respectively, adding and reducing we get

$$\alpha = \frac{x_1(x_0 - x_1) + y_1(y_0 - y_1)}{x_1^2 + y_1^2} + \tfrac{1}{2}\Theta^2 \tag{12}$$

$$\text{and} \qquad 1 + \alpha = \frac{x_0 x_1 + y_0 y_1}{x_1^2 + y_1^2} + \tfrac{1}{2}\Theta^2 \tag{13}$$

SOLUTION TO PROBLEM IN MICHIGAN ENGINEER'S ANNUAL, AUG. 16, 1890.

$$
\begin{aligned}
14 \cos\ 62^\circ &= +\ 6.5726\\
8 \cos\ 43\tfrac{1}{2}^\circ &= +\ 5.8029\\
12 \cos\ 5^\circ &= +\ 11.9543\\
10.25 \cos\ 72\tfrac{1}{2}^\circ &= +\ 3.0823\\
6.43 \cos -168^\circ &= -\ 6.2895\\
y_1 &= +\ 21.1226\\
y_0 &= +\ 21.1226
\end{aligned}
$$

$$
\begin{aligned}
14 \sin\ 62^\circ &= +\ 12.3613\\
8 \sin\ 43\tfrac{1}{2}^\circ &= +\ 5.5068\\
12 \sin -\ 5^\circ &= -\ 1.0459\\
10.25 \sin\ 72\tfrac{1}{2}^\circ &= +\ 9.7757\\
6.43 \sin -168^\circ &= -\ 1.3369\\
x_1 &= +\ 25.2610\\
x_0 &= +\ 24.6410
\end{aligned}
$$

$y_0 = y_1$

$x_0 = x_1 - 0.62 = +\ 24.6410$

Substituting these values in equation (11), disregarding α we have

$$\Theta = \frac{24.6410 \times 21.1226 - 25.2610 \times 21.1226}{25.2610^2 + 21.1226^2} = -0.012078$$

Substituting these same values in equation (12), we have

$$\alpha = \frac{25.2610 \times -0.62}{25.2610^2 + 21.1226^2} + 0.000075 = -0.01438$$

$$\text{and } 1 + \alpha = 1 - 0.01438 = +\ 0.98562$$

$$\text{hence } \Theta = \frac{-0.012078}{0.98562} = -0.012255 = -0^\circ\ 42'\ 7''.8$$

and the magnetic variation $= -2^\circ\ 27' - 0^\circ\ 42'\ 7''.8 = -2^\circ\ 59'\ 7''.8$, *i. e.*, 2° 59' 7".8 East.

Now, multiply the given length of each course by $(1 + \alpha) = 0.98562$ to get the length of true courses and add $-0^\circ\ 42'\ 7''.8$ to the preceding bearings, and we have —

$$
\begin{aligned}
13.7984 \cos\ 61^\circ\ 17'\ 52'' &= +\ 6.6269\\
7.8848 \cos\ 42^\circ\ 47'\ 52'' &= +\ 5.7857\\
11.8272 \cos\ 5^\circ\ 42'\ 08'' &= +\ 11.7689\\
10.1024 \cos\ 71^\circ\ 47'\ 52'' &= +\ 3.1558\\
6.3374 \cos -168^\circ\ 42'\ 08'' &= -\ 6.2147\\
y_0 &= +\ 21.1226
\end{aligned}
$$

$$
\begin{aligned}
13.7984 \sin\ 61^\circ\ 17'\ 52'' &= +\ 12.1033\\
7.8848 \sin\ 42^\circ\ 47'\ 52'' &= +\ 5.3732\\
11.8272 \sin -\ 5^\circ\ 42'\ 08'' &= +\ -1.1751\\
10.1024 \sin\ 71^\circ\ 47'\ 52'' &= +\ 9.5972\\
6.3374 \sin -168^\circ\ 42'\ 08'' &= -\ 1.2416\\
x &= +\ 24.641
\end{aligned}
$$

Refer the latitude and departure of each station on both lines to the starting point, and we will get the following table of corrections: —

	Latitudes, rand'm line.	Latitudes, true line.	Correction.	Departure, rand'm line.	Departure, true line.	Correction.
			North.			West.
Sta. 1....	+ 6.5726	+ 6.6269	+ 0.0543	+12.3613	+12.1033	— 0.2580
" 2....	+12.3755	+12.4126	+ 0.0371	+17.8681	+17.4605	— 0.4076
			South.			
" 3....	+24.3298	+24.1815	— 0.1483	+16.8222	+16.2854	— 0.5368
" 4....	+27.4121	+27.3373	— 0.0748	+26.5979	+25.8826	— 0.7153
" 5....	+21.1226	+21.1226	0.0000	+25.2610	+24.6410	— 0.6200

Correct solutions have been received from Messrs. J. Foster Crowell, Horace Andrews, D. E. Hughes, Wm. M. Whitten, Victor C. Hills, and Hitt & Williams. F. HODGMAN.

THE SANDSTONES OF LAKE SUPERIOR.

GENERAL HISTORY.

WE must, in studying formations, constantly bear in mind that as a general proposition, all those portions of the earth's crust which were above water at any given period, were being cut down, and all those portions which were below water at that time, were being filled up. This is modified by the fact that submerged coast lands were being cut down by shore currents, and upland valleys were occasionally having temporary deposits in them; but these modifications were confined to spots, and were only temporary effects.

This accounts for the fact that, although the different rock formations are piled on top of each other like the leaves of a book, nowhere do we find the book complete. A portion of a leaf is torn out here, and another leaf is torn out there, and so on through the whole thickness of the book.

There is always enough left of any one leaf to show that such leaf existed, and this is made of the materials which were laid down under water during that particular age which it represents. The materials were taken from the uplands of that age, and were torn out of the exposed portions of the earlier leaves.

The rocks of the formations, *i. e.*, the sedimentary rocks, grow more and more homogeneous in composition as we leave the earlier tumultuous period, and approach the long periods of quietude of the later ages of the earth. In the early days, the minerals were all scattered promiscuously throughout the various rocks, and they were consequently of a very complex constitution.

By the slow and quiet operation of ages of weathering and watering, silica has been dissolved out, separated, and re-deposited in piles by itself as sandstone or quartzite; the aluminas and the limes and all the rest of the important minerals have gone through nature's crushing and grinding mills, and have been separated and assorted according to size and weight by nature's sluice-ways and other hydraulic processes. Apart from the mechanical operations of water, there have been vast chemical forces at work to break up the prime minerals so they could be assorted by hydraulic power, and it must be remembered that decomposition is as much a chemical process, as composition. We will consider three prime minerals only; feldspar, hornblende, and augite. The first contains silica, alumina, and an alkali, potash, soda, lime. Hornblende gives silica, iron, alumina, or other base, and augite gives silica, alumina, lime, magnesia, and iron. When the silica has been dissolved out of these and re-deposited as sandstone or quartzite, the other minerals are released and at liberty to form new partnerships and build new rocks.

As will be readily seen from the foregoing, the sandstone formations come under the head of secondaries in the earth's formations. We know very much more about these rocks than we do about the primaries; for we can get at the edges of these all around the whole area. They occur in spots, although to be sure the spots are as large as islands, and almost as continents, in some places. The top surface of the primaries is a surface composed of wrinkled and upturned edges of strata, upon which the calm and placid beds of the secondaries are laid down flat, thus showing sharp division lines.

Sandstone, as will be readily seen from the foregoing, is derived from the primary quartzite, which has been washed down and deposited in new beds during secondary times, and become hardened by time and pressure. The sandstones are found in beds all the way up at intervals throughout the whole secondary series, and the sands constitute at least three fourths of all the mass of mate-

rials in this formation. The principal differences to be seen among the beds are variations in the size of grains. There are four great plates of sandstone between the top of the primaries and the bottom of the great *coal measures*.

The Potsdam Sandstone lies on the primaries, and forms the crest and the western slope of the Blue Ridge.

The Medina Sandstone is the second, and forms the crest and western slope of North Mountain.

The Oriskany is the third great sandstone, and forms the crest and western slope of Capon Mountain, and others in that line of upheaval.

The Millstone Grit is the fourth great sandstone, and forms the base of the coal measures.

The Mahoning Sandstone is the plate that divides the coal measures into upper and lower coals.

The secondary rocks form the country rock of the Mississippi Basin, and they are also found in areas east of the Blue Ridge of the Appalachian Mountain Range. The eastern edge of the Potsdam sandstone caps the Blue Ridge from near Harper's Ferry down past Harrisburg, and on through Virginia and the Carolinas, thence past Cartersville, in Georgia, to the Coosa River in Alabama, near the Selma and Rome railroad bridge. In western North Carolina and southern Virginia, this stone has been terribly tossed up and broken through by the upheavals of the primaries, but it gets control again, and passes under the valley of East Tennessee.

The secondary rocks extend westward beyond the Mississippi to the Rocky Mountains, broken, of course, where the before-named primary upheavals come up through, but the further west they extend, the thinner they get. Rock beds which are hundreds of feet thick in the Appalachian Mountains are represented in Missouri by feather edged beds of but a few feet in thickness, while at the foot of the Rockies many beds are missing altogether.

There are detached areas of the secondary rocks east of the Blue Ridge, which although small, are of great value; for these areas furnish all the brown stone used in building in New York and other cities in the Eastern States. The stone comes from the triassic period of the secondary formation, which is found in troughs in the primary rocks all the way from Nova Scotia down to Georgia, the beds, however, not being found continuous. The northern slope of Nova Scotia is of this triassic age. Shalers'

quarries in Connecticut furnish nearly all the stone used in Boston, Providence, New York, New Haven, and Hartford. The red soils of New Jersey are underlaid with it, parts of the Susquehanna near York, and all the Monocassy Valley are of this formation. The Grant-Seneca quarries are of this formation, and the Virginia Midland Railroad runs across miles of it.

The Lake Superior region has extensive deposits of it, and they are rapidly becoming developed, and extensive quarries are being worked; and in the cities of the West and Northwest this material is rapidly growing in favor.

If we accept recent architectural work, as met with in our public buildings or private residences in cities and towns, as a criterion of the general sentiment in that direction, we shall find that the tendency is to leave the old method of building block after block in one style. Until recently, we have had a monotonous dull-colored variety of stone for facing, whether brownstone, amply illustrated by the general appearance of New York City, or the ordinary brick with marble trimmings, met with in Philadelphia.

We observe with pleasure costly palaces of every variety of design and execution beginning to loom up out of dull rows of monotonous houses. The corners of our principal thoroughfares are showing up landmarks in the shape of business structures, regular piles of masonry embodying the strength and solidity of massive stonework, while the external appearance is relieved by the facing and column work of granite, marble, or a fine variety of sandstone. The residential avenues are fast developing the general aspect of the more noted European cities in their pleasing variety of composition and elaboration.

And yet, after all, aside from the care bestowed upon the actual building operation and the artistic merit of the production, the building stone used, though playing a most important part, is sometimes chosen injudiciously. I have often seen beautiful structures rapidly approaching decay for no other cause than the employment of a stone unsuited to the nature of the work or the climatic condition of the locality. Some of the handsomest light-colored stones, only suited for interior decorative work, have been applied outside with disastrous results, while for a perhaps smaller expenditure a much more durable stone, of an appearance certainly just as elegant, though darker in color, could have been substituted.

The fault will probably lie, in the main, with the desire to obtain beauty at any cost. A judicious selection from a fairly large number of really good building stones that are available, will certainly result in better work and greater satisfaction ultimately to the owner.

In looking over the varieties of stone kept in stock in large establishments, it is found that poor varieties are kept solely because architects will build with them. As time passes on, however, and such buildings show unmistakable signs of decay, these kinds of building stone will be relegated back, and other more durable varieties of rich color or fine quality will come forward into general use.

The Potsdam sandstones of the Upper Peninsula offer a great variety both in color and fineness of grain, and are very extensive deposits; although the beds are not very thick, I have heard of the deposit being in some places 100 feet in thickness. They are, however, pretty generally defective, and a good reliable building stone is a hard thing to find, particularly of the finer and uniform grades of color. They are also in many places filled with large and small pebbles, forming a species of conglomerate with dry seams or strain cracks. These cracks are often imperceptible until after the stone is quarried. There are also clay seams and clay nodules in them that impair not only the looks but the durability of the stone. Another defect is iron seams which decompose, and not only stain, but detract from the strength and durability of the stone. Among the finest quarries being worked on Lake Superior at the present time are the Fuerst & Jacobs Company quarry, and the Portage Entry Red Sandstone Company. Both quarries are situated immediately adjacent to the Portage Entry. There are two qualities of stone in these quarries, the first and the second. The first quality is of an even, rich red color, perfectly uniform in grain, compact and without flaws, and is eagerly bought all over the country. Many public buildings, banks, churches, etc., and the Michigan Mining School at Houghton, are built of this stone.

The second quality of stone is of about the same composition, but the color is not a uniform red. It has white bands running through it, and makes what is termed a variegated stone. This also is an element of weakness in the stone, as the quartz crystals forming the white are a much harder formation than the red, and the stone is liable to split or fracture on these lines.

These different qualities of stone are found in distinct layers, and the work of quarrying them is therefore carried out with considerable certainty. An analysis of the stone gives the following composition:—

	Per cent.
Silica	94.73
Peroxide of iron	3.64
Alumina	0.36
Carbonate of lime	0.69
Carbonate of magnesia	0.75
Water	0.74
Losses, etc	0.09
	100.00

The very high percentage of silica, and relatively small proportion of other ingredients, makes it a remarkably pure sandstone, the peroxide of iron giving it its beautiful red color. These two quarries got out in the neighborhood of 900,000 feet of stone this year.

In speaking of these quarries, I cannot omit mentioning the original discoverer of them, as he is also the pioneer of the Lake Superior sandstone region, Mr. George Craig, now living at Chassell, Houghton county, Mich., born in Yorkshire, England, in 1819, near a town called Huddersfield, where his father owned one of the famous freestone quarries of that district. The son was brought up to the business, and followed it the rest of his life. He came over to the United States in 1854, and applied himself to quarry work both here and in Canada. He was the first to quarry and work the now famous quarries at Marquette in 1860, and the story of his labor to induce capital to take hold of such an enterprise as a stone quarry, would be both a long and interesting one. In 1871, he made an exploration for sandstones from White-fish Point to Iron River, Ontonagon, on the south shore of Lake Superior, examining the outcrop of the sandstone formations. This exploration was made in a small boat and under many difficulties, dangers, and privations. It was during this trip he discovered the now famous Portage Entry quarries, and bought the land where they are situated, which he held for fifteen years, before he could get capital to take hold of it with him to develop it. It is now the leading sandstone quarry of Lake Superior.

The next quarries in importance, and doing the next largest business, are the famous Prentiss quarries, situated near Ashland, Wis.; but although I have seen quantities of the stone, I have not

yet been able to visit the quarries, so I cannot give any particulars about them. There are also some quarries situated on the islands near Bayfield, that turn out some fairly good stone.

The Rock River quarries, situated on Au Train Bay, are rapidly coming to the front as the source of a remarkably fine building material. They are in color very similar to the Connecticut brownstones, and I think they will make, in time, one of the best quarries on Lake Superior. The analysis of the stone is as follows: —

BROWN SANDSTONE.

	Per cent.
Moisture	1.20
Silica	78.90
Alumina	10.56
Iron oxide	5.34
Manganese oxide	trace
Carbonate of lime	1.10
Magnesia	.38
Sodic oxide	1.01
Potassic oxide	.56
	99.05

WHITE SANDSTONE.

Moisture	1.35
Silica	86.25
Alumina	5.34
Iron oxide	2.64
Magnesia	.90
Carbonate of lime	2.65
	99.13

The proprietors of this quarry learned a severe lesson this fall, in losing considerable stone from quarrying too late in the season The majority of sandstones here cannot be quarried to exceed four months in the summer season, as the frost getting into the green stone, cracks it into small pieces, and the stone bursts. This does not occur, however, after the stone once gets seasoned, as it then absorbs but little moisture. As an instance, I have seen large blocks of stone that have lain, for the last twelve years, where part of them were submerged and part exposed to the weather where they had wave action; and yet the texture of the stone was not injured a particle.

The Detroit and Marquette Brownstone Company are opening up a very fine quality of brownstone on Keweenaw Bay, situated about 2½ miles from the village of L'Anse. This stone is of a very rich dark brown color, and almost identical with the old Marquette

brownstone. They have a very large deposit of it; and when they get their quarry properly opened up, I have no doubt they will be one of the largest producers on Lake Superior. The stone has all the requirements for a first-class building stone. (I shall send an analysis of stone later to the Secretary.) The crushing strength, according to tests at the United States Navy Yard, Washington, D. C., on 2" cubes, are as follows: No. 1, 37.418 lbs.; No. 2, 42.582 lbs.; No. 3, 38.110 lbs.; No. 4, 39.349 lbs. The stone is easily worked when green, carving beautifully, and holding a sharp, strong edge, and stands well under the tool. I shall send a sample of this stone, if possible, to the Society.

I will now give an illustration of how money can be lost in quarrying here, and how capital was induced to spend a large amount of money through their own ignorance of the business, and the representations of unprincipled mountebanks, representing themselves as experts, when the veriest school-boy ought to know better. I allude to the property known as the Carp River quarries, and situated but a few miles from Marquette.

The Carp River Valley, in which the property is located, runs in an east and west direction for some distance, with a very rapid fall toward the lake, and is very narrow, being bounded on either side by large hills of quartzite, fissured in many places by veins carrying iron, on which considerable prospecting has been done. The sandstones overlay this quartzite formation, and are now very thin, and in my opinion were never very thick in this valley.

They were evidently left (by these markings) by very rapid moving water and wave action, and before the sands composing them acquired the consistency of stone, large and small bowlders of the original quartzite were rolled into them from the adjoining hights or were carried by water action from higher up the stream. (The stone, what there is of it, is a very pretty brown, but is spotted and blotched throughout with white spots of hard quartz silica, and alumina. This feature prevails in a greater or less degree throughout the whole district where I have examined, and makes it very difficult to obtain any very large deposit of pure red or brown stone.) The stone in this valley lies on the original or primary rock at an angle to the horizon of about 30°, and the beds in the quarries also bear this out, and show that the angle was made chiefly by settlement and not by erosion, as the beds lie almost parallel to the slope of the primary rocks. This ac-

counts for one of the peculiar defects which display themselves in this stone, as all the stone quarried here goes to pieces in irregular prisms almost immediately after being quarried, and shows that it is all lieing under severe strain; and it is this strain that produces the cracks which appear and make the stone so defective. The irregular action which originally placed the molecules together here, showing the wavy and folded layers and markings in the stone, are also an element of weakness. As they form lines of greatest weakness, the cracks follow them in their irregular curves and prisms. Stone of the character that is required for building purposes from the sandstone formations, should be taken from beds or layers which were deposited either in very sluggish water, or laid as a sedimentary deposit in flat and even layers, and in a district that shows tolerably few violent upheavals or settlements which might produce strain. Sandstone laid down in large deposits being massive in its beds and lieing comparatively flat to the horizon, will prove to be generally finer in texture, even in their lines of cleavage and breakage, and more generally homogeneous. True, they frequently carry clay streaks, but this does not always prove a defect, and often proves a benefit in relieving pressure, and making the stone slip on its bed easier. As will be seen by the foregoing, the property just mentioned had none of these features, and from a careful examination of the property and all openings made in its vicinity, I came to the conclusion that there was not a cubic foot of good sound merchantable stone on the entire property. Yet railroads were built, machinery bought, put in place, and operated; and shops, boarding houses, stables, and other buildings erected at great expense; all before hardly any work had been done to prove whether they had a quarry or not; and they never were able to get a ton of sound rock from the location.

There are many explorations being made here for sandstones by both experts and mountebanks, and almost every homesteader in the district claims to have a stone quarry on his location. There is a large amount of money being spent both wisely and foolishly in this business; and although it will result in very many failures, the indications are that some very valuable deposits will be located, and good quarries opened up which will add to the already rich mineral deposits of our State, and to the development of her resources.

HENRY G. ROTHWELL, C. E., M. E.

Mr. Forster.— Do I understand that the writer of that paper claims Mr. Craig to be the original discoverer of these sandstones of the Upper Peninsula? I don't see how in any sense he can claim to be the *discoverer*. For more than forty years I have looked on these same stones. We old men have seen these things with our own eyes, and they have been there for centuries. They only became available when a market was opened for stone of that kind.

BEHAVIOR OF WOOD UNDER REPEATED AND VARYING STRESS.

It is a fact long since noted that a piece of metal subjected to a varying or oft-repeated stress will finally yield at a point less than that found for the breaking stress, had the latter been obtained in the usual way. That is, a piece tested for the breaking load is strained simply once until it yields. If, however, the highest stress is not quite enough to break the piece the first time, it probably will do so with a few repetitions. If the stress is still further decreased, the number of repetitions necessary to produce rupture rapidly increases, until when it falls to the neighborhood of the elastic limit, the number becomes very great, soon reaching a number practically infinite.

The problem is still further complicated, 1. By the way in which the stress is made to vary; 2. By the time during which it acts; 3. By the time allowed between the repetitions.

The stress may vary in the following ways: 1. From a fixed minimum to a variable maximum; 2. From a variable minimum to a fixed maximum.

The above minimum forces may be either positive, negative, or zero. That is, the stresses may vary from high tension to a lower tension, from tension to zero, and from tension to compression, and *vice versa*.

The time of action may vary as follows: 1. Time variation in the act of applying the stress; 2. Time variation in the act of re-

moving the stress; 3. Time variation in the duration of the stress at its maximum or minimum value.

Other minor variations might be mentioned, but the above are the most important. There is no general law involving all these variable elements. The nearest approach to it is known as Wöhler's law, which may be expressed by a formula due to Launhardt, as follows: —

$$M = u\left(1 + \left(\frac{T-u}{u}\right)\frac{L}{M}\right)$$

where u is the maximum stress which may be safely applied an indefinite number of times, the range being from zero to u.

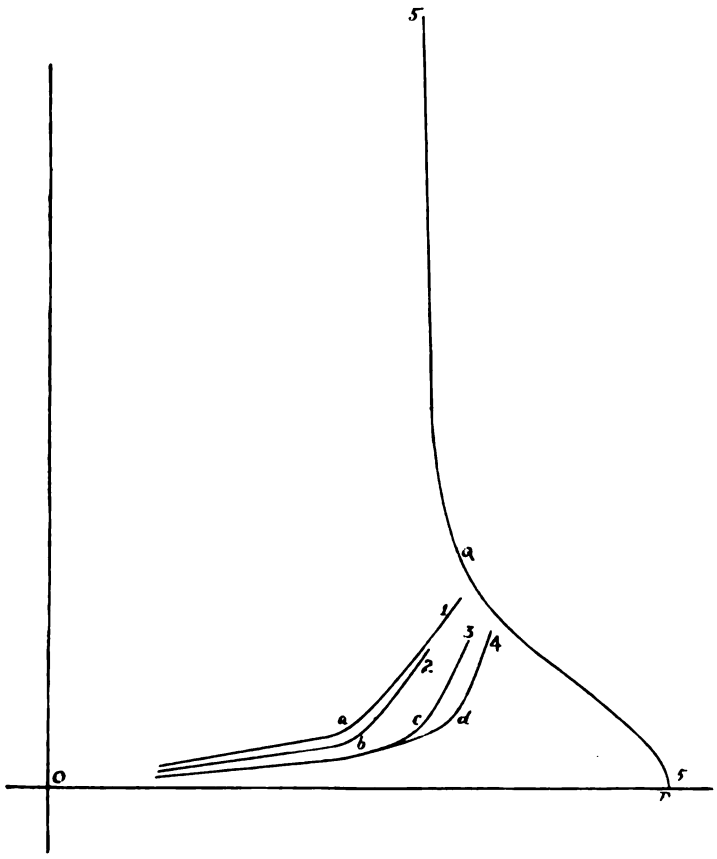
M is the safe upper stress for an indefinite number of applications, the range being from L to M. T is the breaking strength as usually found. In this formula the time elements and number of repetitions are not involved.

Such in general is the nature of the phenomenon usually known as *fatigue*. Metals seem to have been far more carefully examined for this phenomenon than wood. This is but natural, due to the greater use of metals for constructions subjected to varying stresses. The behavior of wood under such stresses is not, however, without interest, and as a contribution in this direction, the following account of some preliminary experiments is submitted: They were made during the summer of 1890 under the author's direction, by Mr. Chas. Ferris, then a senior student at the Agricultural College.

The machine used was an ordinary Fairbanks scale arranged to weigh the reaction arising from the application of the stress. The latter was applied by means of a screw bearing upon an iron shoe, the latter in turn resting upon a wooden shoe to prevent injury to the piece under test. The pieces were all of the same size, one inch square, of well-seasoned white pine, and so cut that the annual layers were parallel to one side. All tests were made with the annual layers in a vertical position. All pieces were supported on roller supports one foot apart, and were loaded in the middle.

It was desired to load them with a certain variable fraction of the breaking load, the number of applications necessary to produce rupture being the corresponding quantity to be observed. An attempt was first made to use as the breaking load of a piece, the mean of the breaking loads of a number of pieces situated contig-

uous in the plank to the piece in question, and apparently homogeneous with it in structure. The results were so irregular, however, as to show that nothing could be learned in this way. An attempt was next made to find some stress which should be in some way proportional to, or representative of, the strength of the piece. It was thought that the stress at the elastic limit might perhaps afford some such starting point; the idea being that this might be obtained without seriously injuring the piece, which could then be tested under loads higher than this by certain known per cents.



The apparatus used was not convenient for making diagrams of the stress and strain, and the length of time necessary for an examination for permanent strain rendered some other method necessary.

This was finally accomplished by using the *time* necessary for the strain to increase by a given small amount, under constant load.

The *modus operandi* was as follows: —

Weights would be placed on the scale beam corresponding to a certain load. The screw would then be turned down, straining the piece, until the stress developed would equal the load indicated. At this point the scale beam would rise. The screw would be so manipulated that the outer end of the scale beam would just touch the upper stop. If under this stress the piece of wood slowly yields, it will be manifested by a fall of the scale beam, which will be more or less rapid as the yielding of the wood is more or less rapid. The ratios were such that a movement of about one inch in the end of the scale beam corresponded to .01 inch distortion of the wood. The time needed for this amount of distortion was noted under the various stresses applied. The reciprocal of this time was the corresponding velocity of yielding. The results found in this way for four pieces are shown in the diagrams 1, 2, 3, 4. The horizontal distances represent stresses, the vertical distances being the corresponding velocity of yielding.

At *a*, *b*, *c*, *d*, a sudden change is seen in the rate of change of the velocity, resulting in its rapid increase, and indicating a point probably not very far removed from the elastic limit, though perhaps somewhat above it. Even if the latter were the case, it was thought to make no difference for the purpose in view so long as the stress was proportional to that at the true elastic limit, or in any constant way representative of the strength of the piece.

With this stress as a starting point determined individually for each piece, a number of tests were made, the means of which are given in the following table: —

Load at Elastic Limit.	Per cent added.	Load.	No. of Applications.	Time.
385	0	385	*a*	½ Min.
385	5	405	23	"
380	10	420	4.6	"
520	15	600	3.7	"

The number a is not known, but is greater than four or five hundred. No pieces were broken with the load at elastic limit, though several were tried.

A further set of four pieces was carefully selected and tested, the results being plotted in diagram 5. The horizontal distances represent stresses, and the vertical distances the corresponding number of repetitions necessary for rupture. At $O\ P$ representing 650 lbs., the number is zero, the piece breaking on the first trial. Below the elastic limit, or at about 450 lbs., it is practically infinite, but rapidly decreases as that point is passed, showing the great effect on the allowable number of repetitions, of a slight change in the stress, or what would amount to the same thing, of a slight change in dimension.

GENERAL CONCLUSIONS.

It will be noted that the pieces were tested for cross breaking only. The duration of the load for one application was usually one half minute, the interval of rest being the same. During the rest, the whole load was removed. In consequence, the stress was from 0 to tension for the under fibers of the stick, and from 0 to compression for the upper fibers. The number of experiments was too limited for any very general deductions, but so far as they go, we may seem to be warranted in the following: —

1. When wooden beams are subjected to cross-breaking under periodic stresses varying from 0 to a maximum, the safe maximum for an indefinite number of repetitions is about the stress corresponding to the elastic limit.

2. If the stress is carried beyond this point, the safe number of repetitions rapidly decreases, reaching a comparatively small number at 5 to 10 per cent increase. W. F. DURAND.

A NEW FORM OF CONTOUR CALIPER.

THE objects sought which led to the devising of this instrument were as follows: —

1. The possibility of telling whether or not the contour or cross section of a pin, axle, or spindle is circular.

2. If not circular, the possibility of finding where it departs from the true or circular outline.

As a necessary consequence of 2, comes the possibility of making an actual map or diagram of the cross section in question.

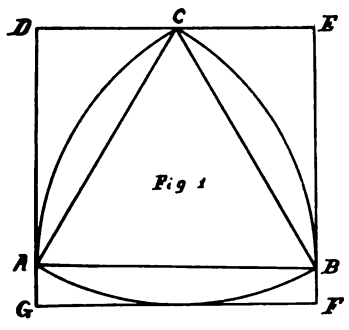


Fig 1

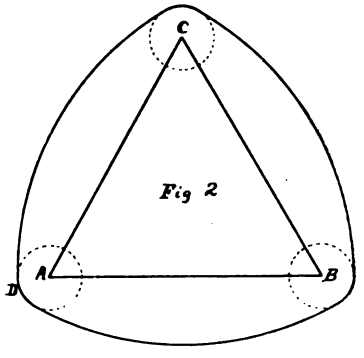


Fig 2

The ordinary or two-point caliper fails in both particulars mentioned.

1. It fails as a tester of the circular or non-circular character of a contour, because it does not discriminate between the circle and other figures of constant breadth. These latter figures in general constitute an interesting class of geometrical forms, of which a few examples may be noted.

In Fig. 1, let $A\,B\,C$ be an equilateral triangle. With each apex as a center, strike an arc with radius equal to a side. The curvilinear figure will result. A little thought will show that this figure has a constant breadth equal to $A\,B$ in all directions, and that with a two-point caliper as the measurer of this breadth, it could not be distinguished from a circle of diameter $A\,B$.

In Fig. 2, let $A\ B\ C$, as before, be an equilateral triangle. With each apex as center, strike a small circle with radius $A\ D$. Then with each apex as a center, strike arcs tangent to these small circles. The curvilinear figure will result. This may be readily seen to have the same properties as the preceding.

In Fig. 3, let $A\ B\ C\ D\ E$ be a regular pentagon. With each apex as center and a radius equal to the distance to the apex nearest opposite, strike arcs. The curvilinear figure will result, which may easily be seen to have the properties of those preceding.

Any regular polygon of an odd number of sides may thus be made to serve as the basis of a figure of constant breadth, and by modifying the sharp corners by supplementary arcs of smaller radius, an infinite number of such figures may be formed from each polygon as a base.

Returning to Fig. 1, let $D\ E\ F\ G$ be a square circumscribed about $A\ B\ C$, the length of side being equal to $A\ B$. A little thought will show that the curvilinear figure $A\ B\ C$ will turn within $D\ E\ F\ G$, smoothly and without looseness or lost motion. It will always have contact at four points, and so far as turning without looseness is concerned, the pair might constitute a plug gauge and its mate.

The three-sided contour with rounded corners (Fig. 2) will also fit perfectly within a square. The five-sided figure, it may be seen, will fit and turn with a sextuple contact within a regular hexagon. In general, these figures will fit and turn smoothly and with constant contact within a regular polygon of a number of sides greater by one than themselves. If then a plug gauge and its mate, both supposed to be perfectly circular, should happen to have these forms, they would still fit with perfect nicety, and no ordinary test would detect the difference. The occurrence of such forms in anything like perfection is not, of course, at all likely in the usual operation of shop-work processes, though the three-sided form with rounded corners is frequently met with as the shape of a hole bored by a flat drill.

We thus see that the two-point caliper does not enable us to state that a contour which has a constant breadth is also circular.

2. In case the indications of the two-point caliper do show a non-uniform breadth, we are not thereby enabled to locate the error relative to a true circular form. In Fig. 4, for example, let the true contour be as indicated by the full line. The caliper being

used across the diameter *A B* will indicate a greater breadth than at any other point, but we do not thereby know whether the excess is at *A* or *B* or both, or if it were the latter, how much of it lies at *A* and how much at *B*. In other words, we are not enabled to make any local correction looking toward the production of a perfectly circular contour.

Let us now leave the two-point caliper, and attack the problem of devising an instrument which shall fulfill the requirements stated at the head of the paper.

Such an instrument, in order to discriminate between the circle and the general figure of constant breadth, must involve as its fundamental principle or mode of action, some property which the circle possesses to the exclusion of all other figures of constant

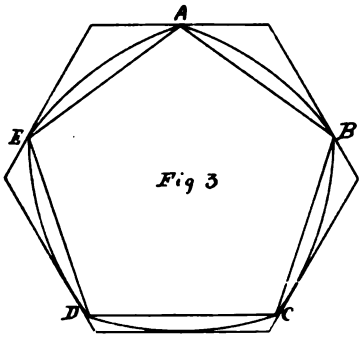


Fig 3

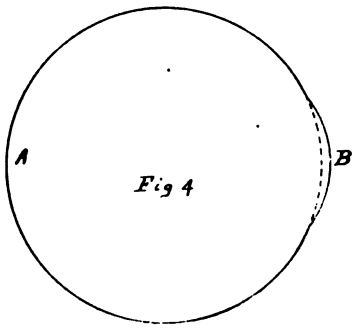


Fig 4

breadth. In order furthermore to make a map of the contour, there must be the possibility of locating its various points relative to some fixed point, preferably in its own plane.

The peculiar property of the circle made use of, was this: Through three points one circle and but one can be passed. In other words, three points which simultaneously touch it in one position will simultaneously touch it in all other positions, and if this is not fulfilled, the contour is not circular. Thus far we have a simple qualitative test. In order to show how it may be made quantitative and the contour thus mapped, we had best proceed to the description of the actual instrument and the method of its use.

P R (Fig. 5) is a metal ring supporting three composition nuts *L M N*. In these work three pointed micrometer screws, *A B C*, with reading heads *D E F*. The screws have twenty threads per

inch, and the heads have one hundred divisions. They are read from the fixed indexes *G H I*, so set as to compensate for the principal screw error. The reading is to one two-thousandth of an inch, and tenths of this may be estimated within a probable error of one tenth either way. The screws are adjusted so that their center lines shall all be in one plane parallel to the lower face of the ring. These center lines must also pass, if produced, through the same point *O*. This need not be the center of the ring, though

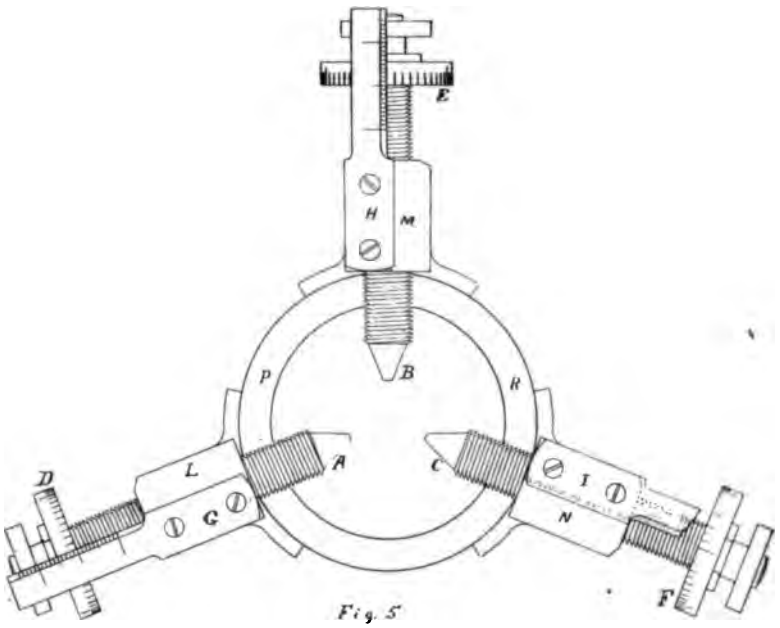


Fig. 5

it is convenient to have it so approximately. The graduations are so adjusted as to read from this point, which then serves as a virtual center or origin for all measurements. The angular openings *A B* and *B C* are each $\frac{5}{16}$ of the circumference, while *A C* is of course $\frac{6}{16}$, or 135°.

Suppose now a piece of metal placed between the points of the screws and held by appropriate adjustments with its axis at right angles to the plane of the ring. Next bring the points to bear on the surface, and so manipulate them that each shall have the same reading. The three points of contact are then equidistant from the

virtual center within, and this point of the metal under measurement will remain as the fixed origin for further operations. As a mere test for circularity, the piece may be rotated between the points. If the motion is firm and smooth, the contour is circular within the limit of sensitiveness of this test. This, however, is not the most delicate test, as will appear later.

To map the contour, proceed as follows: Suppose the piece in position, the three heads having the same reading. Place this reading at the top of three columns marked *a b c*, as in the following table. Place the same readings under *b* and *c* in the second line. Then back off *a* any convenient distance, in order to free the piece for easy rotation. Rotate it counter clock-wise through $\frac{5}{16}$ of a revolution, that is, until the point which was under *a* now comes under *b*, and that under *b* comes under *c*. These two points are

a	*b*	*c*
.8761	.8761	.8761
.8758	.8761	.8761
.8762	.8758	.8761
.8760	.8762	.8758
.8756	.8760	.8762

each distant .8761 from the center, and in their new position they come into contact with points having that reading, and therefore heading for the same point within, which before was the virtual center. Now bring down *a*, and suppose a slight hollow, making the reading .8758. Enter this in the second line, thus completing the second series of readings.

Next carry the .8758 of *a* second line to column *b* third line, and the .8761 of *b* second line to *c* third line, and adjust screws *b* and *c* to correspond to these readings. Then rotate as before, after having slacked up *a*. By this transfer of the readings of *a* and *b* second line to *b* and *c* third line, and the corresponding adjustment of the screws, it may be seen that the two points which gave the readings in the second line, find in their positions for the third line micrometer screws having the same readings. This continual transfer of readings and the corresponding adjustment of the screws, result in a constant preservation of the virtual center referred to above. With every line of readings, *a* gives a new point. After sixteen lines, the original points are returned to, and the measurement is complete.

Column *a* then gives the distances of sixteen equidistantly spaced points from the virtual center within. The order of the

points in the column does not correspond to consecutive order around the circumference, but the latter is readily discovered. Starting with any point as center, and laying off sixteen lines angularly equidistant, we may readily plot the contour to any desired scale. It is usually convenient to use two scales, one representing a circle corresponding approximately to the contour, and magnified a few times. The second representing the error of the

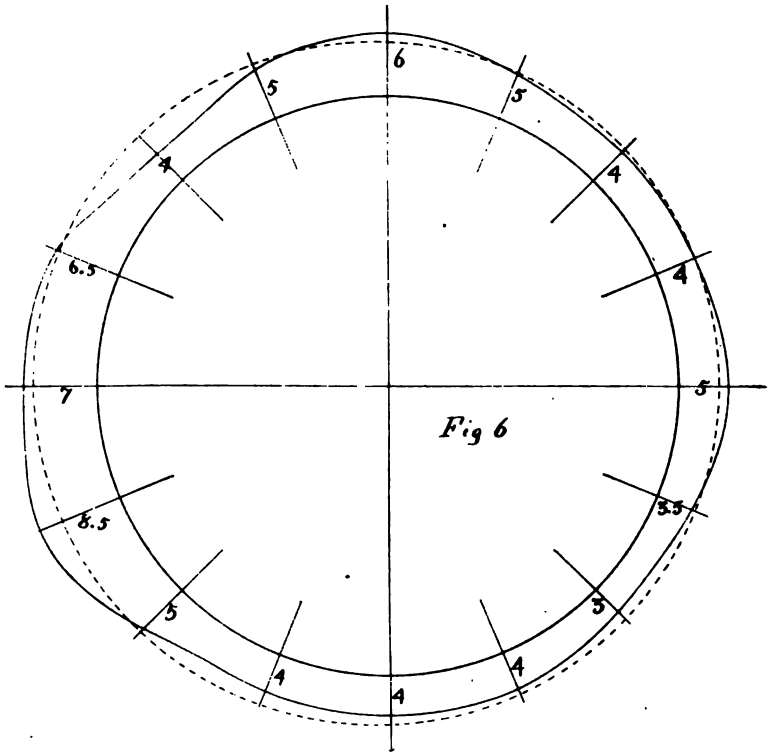


Fig 6

contour relative to this circle, and magnified several hundred times.

Fig. 6 represents an actual contour taken from the feed rod of a Brown & Sharpe Universal Milling Machine. The piece had been apparently finished by grinding, and probably represents about the best results attainable by ordinary machine-shop processes, when no special effort is made to obtain a circular contour.

The full circle is the original datum circle, and represents a circle $\frac{7}{8}$ inch in diameter. The scale to which the errors rela-

tive to this circle were represented, is nearly two hundred times the scale of the circle. The numbers represent the errors in ten thousandths of an inch. This graphic representation enables us to draw a second circle represented by the dotted line which corresponds most nearly to the contour.

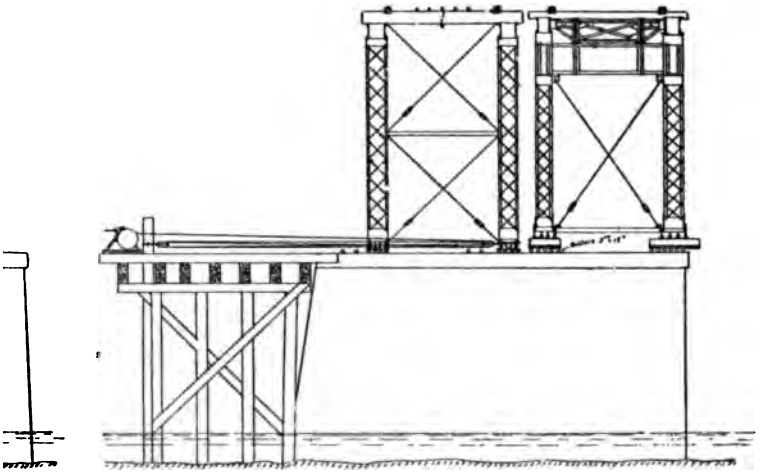
The various diameters which a two-point caliper should indicate, are also readily found, and the contour can be tested in this way. The contour of Fig. 6 was thus tried, and the agreement was well within the limit of relative accuracy of the two instruments.

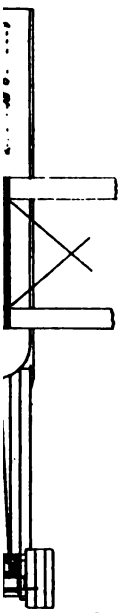
SOURCES OF ERROR.

In the adjustment of the instrument there are three chief sources of error, 1. The inclination of the axis of the screws to the plane parallel to the lower face of the ring; 2. The impossibility of making the three axial lines pass exactly through one point; 3. The index or initial error in the reading of the micrometer heads. Fortunately, these errors and their combination may be rendered entirely inappreciable in comparison with the necessary errors of manipulation.

Without entering into details, it may be said that the necessary adjustments are effected by the aid of a compound microscope and filar micrometer, making possible readings to the one fifty thousandth inch with fair certainty. The errors of manipulation arise chiefly from the varying pressure exerted at the point of contact. To render this constant, several well-known devices are available. With practice and care, this error may be made very small. As the instrument now stands, it seems that the instrumental error is about equal to the uncertainty of the reading, or that on the whole the reading may be in error one five thousandth either way. With larger heads and finer pitch screws, these errors could be considerably reduced.

W. F. DURAND.





ERECTION OF GRAND RIVER BRIDGE
Method of Moving Spans

May 1940

Scale 1/8"-1'

THE ERECTION OF GRAND RIVER BRIDGE.

GRAND RIVER BRIDGE is on the Canada Division of the Michigan Central Railroad. It is a deck bridge consisting of four spans of about 155 feet, with iron trusses and stone piers and abutments. The piers were built long enough for a second track, but the abutments were not.

The superstructure was designed for lighter engines and trains than are even now being run over it, and while it is not considered unsafe, it is thought probable that further increase in the weight of trains will ultimately necessitate its removal. Therefore, when two spans were needed for a bridge on another division having much less traffic and lighter engines, it was thought best to take the superstructures of two spans from Grand River Bridge, and replace them by two new and heavier ones.

In order to avoid delaying trains, it was decided to erect the two new spans on one side, and then pull the old ones out and put the new ones in their place. The material for the new spans and the falsework was unloaded on the bank at the east end of the bridge. A track was then built down the bank to the east abutment, falsework put in place for the two spans, and the track extended across it. Material for the new spans was loaded on a strong lorry, and run on this track down the bank and out on the falsework to a traveler which was used for hoisting it into position. The second span from the east shore was erected first, and ties and bond timbers put on. Temporary extensions were built on the upper ends of the piers and east abutment, long enough to support the old spans when pulled out far enough to permit the new ones to stand in their final position, and to provide room for the crabs used in moving the spans. The ends of the new span rested on the masonry. Rollers three inches in diameter and eighteen inches long were then placed under the ends of the old and new spans. Three flat iron bars four inches wide and three fourths of an inch thick were used for each track for the rollers.

When everything else was ready, the track rails at the ends of the spans were taken up, and the old span pulled to one side by means of crabs and ropes one and one half inches in diameter, running through double blocks. The blocks were then detached from it, and fastened to the new span, which was then pulled into the position formerly occupied by the old one, and the rails laid on it. We had very little trouble with moving either the old or the new span; care had to be taken to keep them from moving longitudinally, as there was very little room between their pedestals and those of the adjacent spans, but by moving both ends alike and keeping the rollers parallel with the trusses, movement in this direction was avoided. The last train over the old span passed at 9:18, and the new one was ready to cross at 10:50, one hour and thirty-two minutes later. Of this time, thirty-eight minutes were taken to lay the rails after the new span was in position.

On the other span, all the rails except the four end ones were laid before it was moved. As the abutment at the east end of this other span was not built for two tracks, it was necessary to extend it to carry one pedestal of the new trusses. The others rested on the masonry. This extension was made with framed bents resting on timber blocking. The new span was built with one truss — the one with one pedestal on these bents — heavy enough for the center truss of a double track bridge, and as Michigan Central bridges are now built to carry very heavy trains, and have an exceptionally heavy floor besides, the load on the bents was about sixty-five tons, which was certain to settle the bents in the not very hard ground under them. Consequently the track was made a little higher on the bents than on the masonry, and jacks were placed under it, to raise it in case it settled more than was expected.

The bents did settle so that the track on them was a little lower than that on the masonry, but we managed to pull the truss on the masonry without using the jacks, after a delay of twenty-five or thirty minutes. The rest of the work on this span was done very quickly, the total time taken being one hour and six minutes The first train crossed the new span seven minutes later — one hour and thirteen minutes after the last one crossed the old span.

After the new spans were in position, their ends were lifted, the rollers taken out, and the wall plates and expansion rollers put in place. The falsework and traveler used in erecting the new spans

were moved so as to be used in taking down the old ones. The iron of the old spans was lowered onto a flat boat, taken ashore, and hauled up the bank by teams to where it could be loaded on the cars. In moving the spans, we had five men on each crab, and four handling rollers at each end, making eighteen in all, besides the foreman and myself, and about fifteen section men to take up and relay the rails.

B. DOUGLAS.

ROADS.

Gentlemen of the Michigan Engineering Society: —

I EXPECT to say something on the subject of roads this evening. I need not refer, except in the briefest terms, to the fact that the public press, everywhere, is full of the subject of road-making. This is the case in Michigan. It is a matter which may profitably occupy our attention for a little while this evening, I think. I believe it will be of interest to see how the general interest in this matter came about; what is likely to be accomplished; and, in a general way, what are the forces at work, as well as what they are likely to accomplish in the future.

But to speak of the subject from the points of view which I have somewhat hastily indicated: The interest in better roads came largely from the American wheelmen. The bicycle needs a good road to run on; and while we may take that as a prominent fact in the case, I think it is not the real cause of the present widespread interest in this matter. The American wheelmen have taken a great deal of interest in this subject; and here lies a little book, called "Public Highways," which is published for free distribution, which you can readily obtain, and from which one may get a great deal of information. It contains Clemens Herschel's celebrated paper on the subject of road-making, says something about pavements, and presents a copy of the legislative enactment prepared by wheelmen for the use of committees in the various States, and which was introduced two years ago into the Michigan Legislature. It will be found, when the history of this movement is studied, that Mr. J. E. Beal, proprietor and editor of the Ann Arbor *Courier*, has taken a very prominent and useful part in dis-

tributing extensively, through the rural papers, matter of interest to all, bearing on this subject, and so disseminating very widely, and where it is most needed, facts and information. I am sure that every one would like to see better roads.

Back of all this, however, there are certain other considerations. The business men have found out that good roads are of great benefit to them. This refers to the hardware trade, grocers, dealers in tools, dry goods, and all staples. We now have the matter reduced to a question of business, and I feel sure something will be done. The carriage-makers want to sell more of their goods; and if there are good roads and much driving, they will sell more. But still more important than this is the fact that good roads are becoming recognized as excellent feeders for the railroads. The railroad men have found this out. Be sure they will find means of exerting an influence in favor of better roads. It is well understood that good roads advance the value of real estate. When real estate men desire to put a piece of land on the market, the first thing that is done is to connect that land with a trade center; in other words, with other more valuable land, by improved means of communication, which means of communication is more commonly a good road than anything else. In the same manner, farms are raised in value by being made accessible by first-class roads. They are also raised in value by having the farm expenses reduced. Let the farmer recall that part of his expenses caused by travel on highways, and let him consider what would be the fact were this divided by almost any number from two to ten. Let him be assured that these numbers are well within the truth, for they are.

Again: There has been a change in the way in which we live. All are knowing to it. Some notice one thing, some others. One change is this: We live more and more off of the cities, villages, and stores, less and less off of home-made products. Many of those who sit here will remember when nearly everything was made at home. I have a very distinct recollection of when shoes were made in the country, at the village and farm houses. Frequently there would be seen on the farm a small building for a shoe shop, standing a short distance from the house, or it was attached to the house itself. These were the shoe manufactories of those days,— the places where the store shoes were made. All our clothing was cut and made in our homes by tailors who went from house to house. The shoe business is a good business to-day,— so is the manufact-

ure of clothing. I simply cite you a couple of instances of the past and present habits of the people. These things are no longer made at home. This is an age of combination, concentration, and transportation. Hence there *must* be lines of communication of all sorts. And here, I think, lies the philosophy of the movement which is felt at the present time, for better roads. Common roads enter more and more into the system of communication. They must take their place and part in the common movement of the age, noted above, — concentration and combination. There are now great manufactories, great centers of storage, great trade centers, great supply points. As a consequence, there must be —

1. A great system of gathering.
2. A great system of distributing.

The common road is the last detail in the extension of this system. It is feeling at last the influence of its place in the plan. Railroads and canals have been built. Waterways have been improved. Telegraph lines have been put up, and the means of verbal communication vastly improved and extended. As a consequence of the great changes already taken place, it is found, at the last, that the common road has a place in this great system of vital trade circulation, and that it must be put on a par with the rest. The common road is the weakest improvement we have. But now it is found that by improved roads the tradesmen and other business men are to be benefited; the railroads (and in consequence, their owners), better fed; that farms and other real estate, are to be worth more; that trade is to be bettered; and that the common road is really a link (and a wretchedly poor link, too, as will appear further on) in the great unifying system of transportation. I have no doubt it will be made far better than we have ever been accustomed to see it. With these interests at the bottom, I cannot perceive any long delay in the coming of good highways.

We are accustomed to hear much complaint about our roads. There are better roads elsewhere, — next town, State, nation, England, Europe, — somewhere else. Now this same complaint will be found running its course in any of these places, if one visits them. It is certainly so in England. We are not to mind this disease. It may not be even a symptom of anything but a chronic tendency to growl. Take a business view of the situation. What are the facts? How can things be bettered? The main facts are

plain enough, and well enough understood. Good roads *pay* in every way. American roads are the commonly cited illustration of what not to do in all countries where they are well known. The more local the plan of taxation and administration, the worse the roads, till in the South they are but wagon trails. The trade of a town or market increases as the square of the distance to which goods, and from which produce, can be sent at a given price for transportation. It costs about the same to carry a bushel of wheat (sixty pounds) a mile on our roads as it does to carry a ton a mile on a railroad. "West of Lake Michigan it rarely pays to grow wheat more than twenty miles from railroad or water transporta tion." (See United States Census 1880.) The profit on wheat raising, then, is lost on the road between the field where it is raised and the nearest market situated on a transportation line. Wheat is only an illustration. All farm produce must pay the same tribute to bad roads. These are a few of the well-known main facts above referred to. The last of them are made equally plain by reference to standard works on road-making. Rankine's "Civil Engineering," p. 624, shows that on a level road it requires a pull to move a load, of from one seventh of the load on soft sand and gravel to only about one seventieth on stone pavement. Gen. Gillmore in his experiments found a variation from one eleventh on a common earth road in fair condition to only one one-hundred and eightieth on best smooth stone tracks. That is, a horse on one kind of road may be able to pull the load of ten on another kind of road.

But we cannot look quite so high. The comparison with the best broken-stone roads shows that a horse can there pull the load of seven horses on a poor dirt road; in muddy times, no doubt, much more than this. Putting this in another form, and using a near-by illustration, the roads in five townships in Washtenaw county, Mich. (a rich agricultural county), in 1889 cost from $18 to $32 per mile, and an average of about $25 per mile. Were these all broken stone roads, well constructed, regardless of classification and say of seven times their present value (and seven is not an excessive number), evidently these townships could spend seven times $25 per mile, or $175 per mile, and still be at no loss. But $169 per mile is the cost of a main road in England, while ordinary roads (as the great bulk of these would be), cost but $58.32 per mile. But these roads are not built of broken stone. Let the most needed few miles be first taken, and the odd $75 taken for

maintenance, leaving the $100 for interest, and it will pay for the use of $2500 per mile to be rapidly expended in making that few miles worth seven times what it is now. But this kind of testimony is really argument, and of an unsafe kind. It can serve but to show us the well-known wastefulness of our present methods. Enough of the facts for now.

What will aid to make our roads better?

Inform those interested what their interests are, the farmer, the tradesman, the railroad man, the fruit grower, the real estate man, and all the rest. Once the people realize the situation, they will find ways to better things.

Another thing: Some powerful interest, like some line of manufactures, the grain dealers, or the railroads, will find it for their interest to secure legislation compelling road improvement.

Still another: The whole matter may be taken into consideration, and the situation studied by our legislative bodies, and measures be adopted meeting the real wants and interests of all concerned.

No doubt all of these forces are at work now in various localities or States.

Whatever changes in our present methods are proposed, to have a value to us they must be based on the existing state of facts, not some ideal condition, or some other circumstances. They must fit us and our surroundings. We now have from fifty to seventy-five miles of road, of various degrees of badness, in every township in the more thickly-settled portions of our State. This is not to be abandoned and new roads built. It is to be put in order and improved. Some of it can be profitably abandoned and rebuilt, no doubt, but this is the exception. We also have a system of taxation which is not to be abandoned, but obeyed, improved, and used for raising funds for these improved roads. So it appears at once that whatever changes we may make, there must still be —

1. Ways and means provided — taxation.

2. Expending the means provided — administration — also including the reports and returns.

I believe our first change should be to a system. The public roads should be in the charge of the best engineers that can be had, and get men who will devote their entire time to it. The second change should be the adoption of a classification of our roads. The third, in the manner of raising the money — the taxation

Those who have special privileges in the roads should pay for them. There may be found some unused sources of income.

We can improve even under our present circumstances. Substitute continuous repairs for our annual "fixing." Place a few men and a team on a district large enough to keep them busy all the time. Have them keep the waterways open and in repair, mend bad spots, pick off loose stones, take out large stones, fill ruts, cut weeds, and the like.

To prepare for changes, and to make them intelligently and properly,—

1. Study the experiences of others.
2. Study our own situation.
3. Plan the changes, if any, afterwards. Whatever changes are suggested must show a reasonable chance of being profitable.

So far as new legislation is concerned, I have little to say. Changes in that line should be based on the same studies and bear the same test as are above noted. I believe, however, we should make our paupers and criminals useful to us instead of maintaining so many of them in idleness or worse, as is now done. They should keep us in roads, as far as their labor will do it. But I mentioned this matter more particularly to you in 1887. (See proceedings for that year, page 111.)

As engineers, we must study the situation. The people desire that their investment shall pay. We must meet that condition — the prime one in modern engineering. Much has already been done to gather facts and information. Here is a book in the form of a pamphlet, by J. W. Jenks, Ph. D., entitled "Road Legislation for the American State," to be had of A. C. McClurg & Co. of Chicago, for 75 cents. This book contains the road legislation of every State in our Union, also an account of the road laws of France (where the best of roads are to be found) and of other countries. It tells much concerning the systems of administration in many places, with a valuable dissertation upon taxation for road purposes.

There is every evidence that this subject is receiving a great deal of attention now; it is coming before the people constantly. In some of the States, colleges are offering special courses in road-making, and holding out inducements of a very special character for young men to come and educate themselves for road engineers. As citizens of Michigan, you doubtless will be pleased to be re-

minded that instruction on the subject of road-making has always been given at our State University for at least a quarter of a century, and has there been considered as a necessary part of the systematic course of training for all civil engineers. The work in the University covers the field, and I have no doubt, though not as familiar with the work there, that the same is true of our Agricultural College here near Lansing.

Now I am well aware that I have touched lightly and briefly on this subject. There are many points and principles upon which I have said nothing. Furthermore, I do not desire to enter into details. You who want reading matter to begin your studies and investigations with, will readily obtain it from the League of American Wheelmen. J. B. DAVIS.

Mr. Steele. — Mr. President, I thank you for the presentation of this subject this evening. I know that practical experience in road-making is a good teacher, and unmaking them will teach us more. There is one element that destroys our roads more than any other, that is, water. Take for instance one case. I live five miles from Traverse City, at a point which might be called summit, over 300 feet above the bay. We cut this part of the road down several feet, and the rains came soon after; and when the heavy loaded wagons came through, at certain places, little holes were started, and more water settled in them, and they gradually got deeper and larger, until they would take in the whole width of the wagon. Now if a man could have been there when those small holes started, and given them some attention, this bad condition of the roads would not have been. Let us have a system of watchfulness over our roads. Employ men for that purpose. They can go along with simple tools, and repair at the right time. Another point I would like to hear discussed. Why would it not be practical to lay a large tile in the middle of the road with lateral branches at lowest points? Then the water that falls there would be taken out quickly, and the road would be left in good order. I think that as a society we ought to take some steps. The roads ought to be in the hands of competent engineers, but of course just as soon as we advance this, the idea will go out, "Oh yes; they want a job." What we need in the State of Michigan just now is a most thorough discussion of this subject. Get the press interested, and you will find that we will soon reap the fruit.

J. H. Forster. — Now it does not seem to be the want of any information, and we should insist on having better roads. I have been pathmaster, but I never was pathmaster more than one year. I don't suppose I let them fool around and every man have his own way enough to suit them. This whole thing is wrong from top to bottom, and I do say something must be done. Whether it will be met by the legislature or some other power, I don't know.

A. J. Teed. — I have given this subject a good deal of thought. It is useless to try to improve our roads by patching up our present road system. If we would have the best roads for the least money, we must make a radical change in our road laws. I do not agree with our President that all improvements in roads must be made on the present highways as they are now located. In the newer parts of this State there are many roads yet to be laid out; in the older parts of the State highways are being continually changed, so that much may be done in the way of better location. When a railroad or a lumberman's logging road is built, it is located on the best ground; but when a public highway is laid out, you cannot convince the settlers that it belongs anywhere except on the section lines.

The great trouble in our road system is that it is too local. Roads are laid out and worked to accommodate the immediate wants of the adjacent settlers, with little reference to the needs of the traveling public generally, or to future requirements. A second defect in our road laws is that the Highway Commissioners are not experienced road builders, and their tenure of office is too short to enable them to acquire this experience.

A third defect in our road system is the want of concert of action between the local road districts of a township and between the different townships of a county. These three defects might in great measure be remedied by putting all the principal highways and all the highway bridges of a county under the control of a commission of experienced road builders, one of whom should be a civil engineer. If the location and construction of the roads was under the supervision of experienced men, it would not matter so much how the tax was collected.

Mr. Hodgman. — The only way to have our roads properly improved is to keep agitating and educating. People do not, as a rule, realize the cost of bad roads. As a rule, it costs less to make good roads than it does to pay out nothing for making

them, and have bad roads. I have several times made estimates of the cost of bad roads, and placed them before the people of my vicinity: but keep it as low as you can, the aggregate is so large as to be received with incredulity and a shake of the head. For instance, the township of Climax has about 72 miles of road. On one of the best miles of this road a man once hauled 142 bushels and some odd pounds of wheat with two horses and a wagon at a single load. Eighty bushels per load can be hauled on that road the year round as an average. But take it the township through, and the wheat buyers tell me the loads do not average over 30 bushels. Suppose it were 40; then half the time spent in moving everything that is hauled over the roads is wasted, because there is not a mile of road in town but what can easily be made as good as the best mile in it now, or very nearly so. The amount of produce, etc., of all kinds hauled on these roads, amounts at a low estimate to the equivalent of 200,000 bushels of wheat. The distance hauled will easily average 5 miles. Now by hauling only 40 bushels instead of 80 per load, there is a dead loss of 2,500 trips,— time of men and teams,— besides the wear and tear which is so much greater than on good roads. If we call the distance hauled 5 miles or 10 miles for the round trip, then there is wasted enough to equal a trip with a loaded wagon half way around the earth and back again empty. If we call 15 miles an average day's work for a team on such roads, and figure the price of labor of man and team including all expenses at $3 per day, then it figures up that we are wasting $7,000 a year: that is, our bad roads are taxing us that much every year. If we had that in money to be applied economically on the roads, it would be but a very short time until every road in town would be as good as the best now in it. What is really wanted is a money tax to be laid out under the direction of competent roadmakers.

THE GRADIENTER.

At the Kalamazoo Convention of this Society, a paper was read on the gradienter, in which the author called special attention to an alleged fallacy in its construction, which was likely to lead to errors in its use. It was sharply discussed pro and con and withheld from publication by its author, until he could rewrite it to meet the arguments which were opposed to it. It was not returned in time for publication in the proceedings of that year, and went over till last year, when it was sent in and published without discussion in the "Annual" for 1890.

As I consider the gradienter an exceedingly valuable attachment to the transit for use under certain conditions and in certain places, I dislike to see any unnecessary discredit thrown upon it, and hence I enter an objection to the subject-matter of that paper of a different character from any presented at the time of its discussion. I will not repeat the Author's argument, only his conclusion, which is that "this erroneous principle always gives distances too small *except* [italics mine] *those determined with angles under about 3°.*" To which I reply that the exception covers the entire range of the instrument under the conditions in which it is ever likely to be used. It is of no earthly consequence to anybody whether there is or is not an error in the instrument outside of that range. Let us consider a little the uses to which a gradienter is put. In my opinion its greatest value is for use on railroad location in an open country, where it is a most valuable assistant in selecting the position of the line to be located.

An adjustment of the instrument and a glance at the gradienter tells the locating engineer in feet per hundred just what kind of slope he has to contend with, and if it be in a mountainous region where a certain grade line has to be fitted to the ground, it tells him at a glance, without waiting for the leveler, where to find the ground to fit his grade line. I have found in work of this kind that the gradienter saved nearly, if not quite, half the time of the

party; in other words, that I could get nearly twice as much accomplished with it as I could without it, because of the saving in preliminary work by being able to locate the line in the right place the first time trying. When a locating party is costing the company $600 to $1,000 per month in the field, this is an important item. And yet the steepest line of this kind I ever had to run was on the west slope of the Wasatch Mountains, where we had for several miles a continuous rise of 3.8 feet per hundred.

A 3° range on the gradienter gives a 5¼ per cent grade, which is steeper than any ditch, canal, or railroad grade that I know of outside the rack railroads.

Another use of the gradienter is to measure distances; somewhat similar to stadia measures. When used for this purpose, a graduated rod — generally a leveling rod — is used with the transit. If the rod is one hundred feet from the instrument, one foot space on the rod is all that is used. Three degrees cover 5.24 feet. If the rod is 1,000 feet away, which is about as far as such measures are commonly taken, ten feet space on the rod is all that is required, if we use a foot in a hundred. Three degrees give a range of 52.4 feet, which is a longer rod than I ever knew a man to carry.

While on this subject, it may not be amiss to say that the vertical circle or arc may be used in place of the gradienter with only a little extra trouble. We have only to change degrees and minutes of arc into feet per hundred by use of the table of natural tangents. Thus if we wish to run a grade line of one foot in 100, we find in the table of tangents the corresponding angle to be 34½′. Or if we find the ground ahead of us to have a slope of 24′, we see by the table that it is seven feet in 1,000, or ¾ per cent. This may seem a simple thing to refer to. Other surveyors may be quicker to "catch on" to a point than I, but I had run transit with vertical circle and without gradienter on railroad lines a good while before I thought of this application of the table of natural tangents. In fact, it took me a long time to get rid of a feeling that somehow it took a different process to solve a triangle when it stood up, than when it lay down. F. HODGMAN.

A. J. Tod.—I have been using a gradienter for the last two years, and find it very convenient in leveling up and down hills and over logs. Where extreme accuracy is not required, by setting

the gradienter at some convenient angle, as one or two feet in a hundred, and then making the necessary correction in the rod reading, much time can be saved in moving the instrument. For convenience, the transit should be set over or near a station.

F. Hodgman. — I will add to what has been said, that I think the gentleman who wrote the paper on the "Fallacy in the Gradienter," started out with a false premise, which vitiated the entire argument. This is the way he states the premise: —

"The theory of this machine — or attachment to our transits — is *that the variation in the angle of elevation of the telescope, varies strictly with the number of revolutions of the tangent screw.* So far as the *sine*, the *chord*, the *arc*, and the *tangent* of an angle may be regarded as equal, the above law may be regarded as true."

But that is not the theory at all. In every description of the gradienter that I have seen, it is expressly stated to the contrary. For instance: Young & Sons, in their description of the gradienter, say, "The number of revolutions and parts of a revolution as indicated by graduations in the screw-head, measures the grade from the level, *not in terms of arc*, but in measures of base."

The gradienter does not measure angles in degrees and minutes, but measures a base in feet and hundredths, and does it correctly throughout its entire range. No engineer need to fear using it at any angle within its reach.

ENGINEERING FOR LUMBERMEN.

ENGINEERING for lumbermen, so far as its special features are concerned, is a growth almost entirely of the last ten years. Fifteen or twenty years ago the lumbermen of Northern Michigan had very little use for a surveyor. In fact, the less they saw of one, the happier they were. Land was cheap; timber was cheap; and no one wanted to know where his lines were, nearer than the land-looker could show him; and as for the engineer, they had no use for him. As timber increased in value, so increased the anxiety of the lumberman to get every tree that belonged to him; and he knew too well by experience, the consequences of taking a tree that he did not own; hence accurate land surveying has taken the place in the woods, of the guess-work methods of twenty years ago.

A dozen years ago the logs were mostly hauled on the snow over well-graded and finely-constructed sleigh roads, the laying out and construction of which, though well and neatly done, required no greater skill than was to be found in any well-regulated lumber camp.

That is all changed now; most of the timber to-day is hauled over logging railroads often from twenty-five to thirty miles in length.

In new counties also, around the mills, villages spring up. The lumberman's engineer, in connection with laying out a railroad and mill site, is often called upon to stake out a town. I have not unfrequently been required to survey land, run railroad lines, and stake out village lots, all in the same day, and with the same set of instruments.

THE EMPLOYER.

The engineer usually has very little to do with the proprietor of the timber. Sometimes he does not even see him. The man the engineer has to deal with is the general superintendent. This man is usually intelligent, well posted in his business, a good

judge of human nature, and withal a very pleasant man to deal with.

In all minor details, the engineer is generally left to the exercise of his own judgment. But the superintendent has a very definite idea of what he wishes to accomplish, and he can very quickly tell whether or not his engineer is equal to the emergency. It is useless for an inexperienced fraud to impose himself upon the superintendent of a lumbering firm. His inability will very soon be discovered, and he will be invited to move on to another job.

CHARACTER OF THE LUMBERMAN'S ENGINEER.

The lumberman's engineer must be a thoroughly competent land surveyor, always ready for any emergency, and must never make any mistakes. In railroad matters, the engineer must not only understand the principles of locating a railroad, but he must be well posted in the peculiar requirements of a logging railroad. He must know what grades and curves are admissible; how much it will be advisable to expend in grading his road; and how he can reach the timber so that it can be the most economically moved.

He has not only to consider the route as to the cheapest and best place to build the railroad, but he must also consider how the logs can be the most economically placed on the cars. It is not always the cheapest railroad to build that is the cheapest for the lumberman. The expense of getting the logs on the cars is often more than that of hauling. A difference of five cents per M. in skidding and loading will often pay for building a long piece of road.

I laid out a road for a Manistee lumberman last summer where a difference in cost of five cents per M. in getting the logs to the mill would amount to over $10,000. We had a choice of three routes, and the problem was not only to decide which of the three routes would take the logs most economically to the river, but as there would be a difference in the cost of driving the logs on the river and of hauling the supplies to the camps, according to which route was taken, this also had to be considered.

The pine lay in a belt two to three miles wide, and about eight miles long, parallel with the Manistee River, and about five to six miles distant. It was necessary to look over this whole tract of

country both with a view of determining the relative cost of building the road, and of hauling the supplies by the different routes. We solved the problem, but we were greatly facilitated in doing so by the stubbornness of a Dutchman who stoutly refused to allow us to build the railroad over his valuable piece of sand.

The lumberman's engineer must know many things not found in the books, and many things that he can learn only by experience; and that experience is too often learned at the expense of the lumberman.

KIND OF TOOLS NECESSARY.

In going to and from his work, the engineer has frequently to ride thirty or forty miles in a buggy over a rough road, and it is convenient not to be loaded down with any more tools than are absolutely necessary. For this purpose a light transit with level attachments and a good needle, is the best instrument; with this, one can do any kind of work required, and it is not convenient to be encumbered with two instruments. A 100-foot chain is the best for measuring. It is well to carry along a tape to be used when accuracy is required. As the assistants furnished are always inexperienced men, it is necessary to use a self-reading rod, which for the sake of portability should fold up to a length not greater than seven or eight feet, and be capable of being extended to twelve or sixteen feet.

About all the other tools absolutely required are a pocket compass, a hand level, a pocket set of drafting tools, a supply of profile paper, a little quinine, and a good supply of oil of tar. The last article is sometimes quite as necessary as the transit.

METHODS OF WORK.

In methods of work, engineering for lumbermen possesses these characteristics: *First*, That the work be rapidly done. No puttering or fussing over some ideal nicety can for a moment be tolerated. *Second*, While the work does not require extreme accuracy, the engineer, like Gillespie's needle, must never be very wrong. The work must be done on correct principles. A good needle line and chain measurement, if the method is correct, will never get the lumberman or his engineer into any trouble. The engineer must go fast and go right. Unlike farm lines, the lumberman makes no attempt to perpetuate his lines and corners after the timber is cut.

As soon as the timber is removed, the fire runs through the woods, and soon obliterates all traces of the survey. The government corners of course should be carefully perpetuated; but it is not worth while to spend much time on the interior corners. They can be better set when they are wanted, if they ever are.

In railroad building, I generally commence my work by taking a pocket compass, a hand level, one assistant with an ax, and look the country carefully over, blazing those places that seem to be the proper places for the railroad. When I have thus gained a general idea of the country, I run a random line where it appears to be the best ground, and take a level on it. And then in the evening, so as not to take the time of my assistants, I construct from the notes of my random lines, if the grades are satisfactory, a set of notes from which I can locate my line just where it is wanted, with no further calculations than can be made mentally in the field.

In running the random lines, I note all those places where the line must pass, and in locating run the curves with reference to these points.

For example: Suppose I have been running a 4° curve, and when I get around parallel with my next tangent, I find I am 10 or 20 feet to one side; instead of going back and re-running the curve, I note what change in the course of the tangent would be necessary to carry me through the next pass. I then lengthen or shorten my curve sufficient to make the requisite change in the next tangent, and go ahead. For this work I find a good set of traverse tables very convenient. After my line is located, I take my levels, and that is often the last I ever see of it.

Except in rare cases, no cross-section or calculation of earthworks is ever made. Nothing but the center line is staked out; of this I furnish the foreman of the camp a profile with the cuts and fills for each station marked on in figures, and the foreman or his grader works out the line with no further assistance from the engineer.

GRADES AND CURVES.

As to what grades and curves are admissible on a logging railroad, it is difficult to give accurate data, so much depends on the circumstances. The engineer must find out what kind of engine it is proposed to use, how much pine it will be necessary to haul in

a day, the total amount of pine to go over the road, and, lastly, the size of his proprietor's pocket-book; for frequently the lumberman does not think himself able to build such a road as the engineer might think the most economical.

As to curves, any curve on a steep up grade is very objectionable: and a sharp curve at the foot of a steep down grade should always be avoided. If a train gets to slipping down a steep grade with a sharp curve at the foot, it is very liable to jump the track. A 4° curve on the whole is a very good curve; it is not so sharp as to be objectionable, and is very easy to run. From that up to 8° or 10° will be allowable where there is not much grade. For a direct action engine, on the main line, I would never put in a curve sharper than 8° or 10°, and never sharper than 4° or 5°, unless the nature of the ground requires it. With a geared engine, when the ground requires it, a 16° curve can be worked over with perfect safety by running slow.

On a road where I did some work, an engineer put in a 16° curve at the foot of a long grade where it was desirable to run rapidly. The ground was level, and a 2° or 3° curve could have been laid as easily as the one he laid. More accidents have happened on that curve by engines and cars jumping the track, not to speak of loss of time in being obliged to slow up the train in going around the curve, than the time of the engineer was worth for a year.

In regard to grades, so much depends on the character of the engine used that no definite rules can be given. And yet it is often very desirable to know just what can be done in particular cases.

This can be answered best by giving a few examples of what has been actually done, and leave the engineer to draw his own conclusions in his particular case.

With regard to engines, the Shay geared engines will haul a greater load over a hill than any other form with which I am acquainted, but they are slow. I have seen one of these engines, about 12 tons, haul 2 to 3 cars up a 4 and 5-foot grade, and handle 6 to 8 cars down a 5-foot grade, with no accidents. This same engine has for the last 2 years been successfully working a train of 15 cars on a long down grade of $2\frac{2}{10}$ feet. They have never had any accidents since the track was properly ballasted, but I do not think it would succeed if the grade were over $2\frac{1}{2}$ feet.

Another of the geared engines of 7 tons pulled all the pine of a half section over a hill where the grades run from 6 to 9 feet in a 100; but it could not haul over one or two cars, and sometimes not that. When the track was wet, the down grades were not safe, and they had a good many accidents. One of these engines will do very good work switching over hills of 4 to 5 feet, but on the main line, when a full train is to be hauled, the grades should be less than 2 feet up and 2½ down.

On another road, where they use a 12-ton Porter engine, there is a grade of one foot with a 4° curve at the top; total raise, 20 feet. The regular train is 15 cars, but when the track is wet, the engine cannot make the top of the hill without taking a run of at least ½ mile. On this same road with a 14-ton Porter engine they can haul up a one-foot straight grade 30 cars when the track is dry, but will sometimes stick with 20 cars when the track is wet. But on a $1\frac{6}{10}$ straight grade this same engine makes 2 trips for 18 cars.

On another road a Boulchis engine, 22 tons, hauls 6 to 8 cars up 3-foot grades for its regular trains. I have seen a 19-ton Mogul engine haul 10 cars up a 2½-foot grade at the rate of 8 miles per hour, but this same engine in trying to come up a 4-foot grade with 3 cars slipped, and went to the bottom.

The best work of which I have any accurate data is being done on a road that I surveyed this summer. This road goes over a hill 150 feet high. The last 1,200 feet of the up grade is 3′ per 100. The first half of the down grade is 2′, and the last half is 3 feet per 100, with 2 16° curves. Over this hill a Shay geared engine of 30 tons on the drivers, with 3 10 x 10 cylinders, is daily drawing 15 cars of 2 to 3 M. feet each. This engine can draw 2 cars up 27 feet in 300.

These cases which I have cited are all extremes, and not to be recommended only when the necessity of the case requires it. My rule is to keep the track as near the surface of the ground as I can, for economy's sake; but I never put in any curves or grades that I do not know are perfectly safe without first consulting my employer.

A. J. TEED.

Prof. Davis. — We are often told that the pine is fast disappearing, but there is a great deal of pine coming out yet, and there are a great many useful methods being used in getting out the pine. The result will be more science used in this field, not only for get-

ting out pine but other timber also. So it is not only a favor for us, but it is for the benefit of those who will come after, who will have much more to do than we.

Mr. Teed. — In regard to hand levels, I had occasion a few years ago to take the levels on a line about five miles long with a hand level; afterwards this same line was run over with a standard level, and I found that my hand levels were nowhere more than two feet out. It is my custom of late years when I come to a steep bank of a river or ravine, first to set a peg on the opposite bank with the standard level, and then level down and up the bank with the hand level. I generally come out within one-tenth. My level is one of Gurley's first make.

It is surprising how good work can be done with very poor tools, when occasion demands. On one occasion I had broken my level, and while it was being repaired, I took a common level vial obtained at a store, tied it to a stick, and attached this to my transit. It was not very sensitive, but I took my levels, taking short and equal fore and back sights, and when the road was graded, you could not tell the difference by the looks of it.

Prof. Davis. — In regard to what Mr. Teed has just said, I will say, I suppose all of us are familiar with similar experiences, where we have run our peg levels over certain lines, and have gone back and compared our elevations of the pegs both ways. Mr. Teed is certainly sound in using his bottle.

MAPS FOR THE USE OF ASSESSORS IN VILLAGES AND TOWNSHIPS.

To the President and Members of the Michigan Engineering Society: —

WHEN our genial Secretary, in his innocent way, invited me to "suggest a topic for discussion at our annual meeting," I little thought "it was loaded," or that I would be "hoist by my own petard," with an official order to prepare a paper on the subject so suggested. My idea was to receive rather than impart information.

Some experience in preparing maps and plats in connection with the decennial appraisements in the State of Ohio, and several terms as supervisor and city assessor in Michigan, have caused me to devote much time and no little thought to this subject. I trust it will be possible to so increase the general interest in it as to lead to some action by our Society through its legislative committee or otherwise, looking to enactments authorizing in each and every county a complete set of town and township plats suitable for assessment purposes. As this means work for the individual members of our Society as well as the fraternity generally, besides a great convenience and safeguard to every property owner in the State, there should be no opposition, but a united effort to gain the end sought.

My ideas are based largely on the Ohio laws and practice, although I do not commend the decennial appraisement system there in vogue. This fixes a value upon each parcel of land once in ten years, which value remains unchanged and unchangeable for the next decade, as inelastic as the law of the Medes and Persians. This is hardly adapted to the requirements of a new and rapidly-growing community, or, for that matter, an old and decaying one, either.

Section 2789, Revised Statutes of Ohio, provides that the county commissioners, who hold the same powers (with monthly or semi-monthly meetings) as our boards of supervisors, may authorize the auditor to advertise in one or more newspapers for sealed pro-

posals to furnish suitable plats to enable the supervisors and assessors to correctly appraise all real estate. Contracts are awarded and bonds required for their performance. These plats are kept by the auditor, and tracings are furnished to the township supervisors, assessors, etc., of the various localities. By this system uniformity is preserved, and mistakes in description, either in assessing or in tax-paying, are largely eliminated. In our State the county treasurer would be the proper custodian, and all transfers of title to real estate could easily be made upon the plats, or by marginal reference. So much for the laws required.

In regard to the making of maps, it is hardly to be expected that I can give the members of this Society any advice or information. Some points to be observed are these: A good quality of mounted or muslin-backed drawing paper should be used for original plats, the best of India ink for line and letter work, and color, sparingly, if used at all. A light marginal shading of Prussian blue laid on with a brush, where there are large water fronts or surfaces, will save time and labor, and add to the appearance of the plat, if well done. Tints may be used to distinguish additions, subdivisions, etc., where a number of parts of several appear on the same sheet; but avoid poor colors, and unless one has experience and some artistic ability, the pigments are more useful in obscuring poor workmanship than in adding to the beauty of the plan. Headings may be stenciled in when one has a losing contract. Almost any well-equipped newspaper or job printing establishment can do very satisfactory work in printing headings, and much cheaper than letters can be designed — unless the foreman is very drunk and spoils one's whole plan, as I have had him do for me. Make as neat and artistic a heading as you can afford; for nothing adds more to the appearance of your job — unless it is the rest of the workmanship.

Scales are important, and are usually prescribed in the contract. Usually the first thing the lucky bidder sets about is to have his contract modified in this particular. The scale should be governed largely by the size of the tracts to be mapped. In township work where farms are large, it is an unnecessary waste of paper and material to use the same scale as would be required where the parcels are small. I would recommend for general use in country work scales of 10 and 20 chains, and in village or city work, of 50 and 100 feet, and even as small as 200 feet where lots

or tracts are quite large. Index sheets on a small scale, showing the entire area mapped, should accompany each book; they may show by tints and figure the space covered by the correspondingly numbered page of detail work. Plainly print or write the owner's name and the area in each tract or parcel, showing dimensions or distances, courses or bearings, as far as known, where they belong. In village and city work, get lots and blocks numbered correctly, show width of streets and alleys. Don't be hoggish, and take up all the room, or get your half in the middle of the plat, to print names and area; leave the assessor a place to put valuations on, make changes, etc. The tracings may be made on certain qualities of bond paper, but tracing-cloth or linen is much more durable and satisfactory, and will last the assessor several years, if carefully used. Changes in ownership and value can be made and compared with the originals at the county seat.

I am aware that we already have laws in Michigan which make it possible for maps to be made for assessing purposes, but I consider them lacking in many particulars, and valueless in promoting system and uniformity in this important work.

While I think no one will deny the utility and convenience of such plats, I expect to hear somewhat of the expense involved. The legislation needed is not of the compulsory kind; it is only requisite that it provide that such plats may be authorized by the proper officials when and where the demand exists. Then the cost may be considered, and I apprehend that will not prove such a bugbear as is usually feared. It will not prove much more than is incurred under the present system, by which the plats made have no uniformity, no specified custodian, and soon become worn out and lost. I have seen hundreds of dollars' worth of valuable maps, plats, and records which had been chewed up and utilized by rats and mice in the construction of comfortable nests, all for the lack of a proper legal custodian. The bids for such work in Ohio counties range as far as my own personal knowledge extends, from $500 to several thousand dollars — $15,000 to $20,000 in the counties of Cuyahoga and Hamilton, containing the cities of Cleveland and Cincinnati. The State of Michigan being almost entirely sectionized and most of the counties of moderate size, with small populations and large farms, the expense would be light here in comparison with the cost of such work in Ohio.

ELI L. HAYES.

Prof. Davis. — Perhaps I might say a word with regard to this paper. I think our plat law should be extended to all the land in the State. We should require the use of that plat law or its like everywhere. Every sale of land should be made by a recorded survey. Future sales of those pieces of land should be made subject to the recorded plat thereof. It would be found that the expense in connection with real estate conveyances would be very much lessened in a short time.

Mr. Forster. — Mr. President, I may be very dull, but I don't see now why if I should want to sell my farm, that it would be necessary to go and hunt up a surveyor and pay him to survey it. I know my bounds exactly, and all of my neighbors do. I know where it is, what range, what township, and what section.

Prof. Davis. — I will explain. It is not possible that all farms are in as good shape as Mr. Forster's. But we will suppose they are. Now Mr. Forster will die some time, and as time passes, his farm will change hands. Now there should be a record on file which will describe the exact location of it. While Mr. Forster himself knows all about his bounds, and is satisfied they are right, there is nothing on file to convey the same satisfaction to others.

ON SEWER CURBING.

Mr. President, and Gentlemen of the Convention : —

LAST year I was requested by some of our members to write a paper on sewering in quicksand, with a description of a method of curbing. The subject being somewhat old, and being afraid of its being flavored with chestnuts, I did not respond; but as the request has been repeated this year, I will, as briefly as I can, give a method that has been very successful with me. Of the sewer itself I will say nothing; but take the matter up at the point when the guides are set, and digging is ready to commence, premising the sewer is deep, and in quicksand some feet at the bottom. The most important part to be attended to is the surface ground that overlies the quicksand. To hold this in place, and prevent cracking and crumbling, is of the first importance.

The trench must be perfectly true, the banks free from humps, so that the curbing may bear evenly against all parts. Poor workmen don't do this good enough as a general thing. Did you ever see a poor workman? — I mean a man who could not dig a good sewer trench, letting him be the judge?

I have found but a very small per centage of men who ought to be intrusted to make the banks of a sewer and shape them to fit the stringers, as we call the horizontal planks we use for the work. These should be of good, strong lumber, tolerably free from knots, as they must bear the strain of the braces being as far apart as possible, to allow the workmen room to put up scaffolding. If the trench is deep — say if 12-foot plank is used — the braces would be about 5 feet space in the clear to work in, which is rather small. Fourteen-foot plank would be better.

If 16-foot plank were used, it would likely need a brace at each end, and two at equal spaces, unless the plank was thick and unduly heavy. This horizontal curbing is used as far down as you can depend on the bank to stand, while the ditch is deepened the width of a plank on each side. These should be put in very care-

fully in panels. Don't break joints. If put in exactly over each other, they can be used over and over again. When the trench is filled up, the panel is taken out. Commencing at the bottom plank, loosen the braces, throw them out, slide the plank backward, and fill in the earth. The man in the ditch loosens the next plank, and so on. The planks last for a good many sewers.

By keeping the backfill well up, moving lumber very far ahead is avoided, and you don't need so much curbing. Leaving lumber in a sewer is a waste. I never left a plank behind in my life. This supposes your workmen are handy men, and are not afraid you are going by faulty arrangements to bury them alive. I have found it hard work to make men careful enough at the top; but if this is neglected, and as they get deeper, the work looks pokerish, and some of the curbing lets dirt down behind it, and shows signs of loosening, then the men in the ditch will look up frightened. They get nervous, and lose confidence in the safety of the place. Then you are in a bad box. Your top has become loose. You can't change your bracing timber. Every move seems to make it worse. When a shovelful is taken out, there are ten ready to fill in its place. Now comes danger to adjoining buildings, and a perplexity, toil, and expense which may generally be avoided if skill and care are exercised, all the way down. I have been in this condition only when men in my absence have neglected to properly curb the top.

Of course there are many places where curbing is only a nuisance; but we are laying a sewer in a quicksand bottom, and we are now supposed to be as deep down as the earth is sound. It may be two feet, or it may be six feet, it makes no difference. Our walls are nearly perpendicular, or only just slope enough to make braces perfectly safe, perfectly true. The curbing touches almost every part of the earth behind it. Every brace is tight, and in a vertical line with each other. This is important. We want every inch between braces, to get up the remaining earth in the trench, to get down the brick, mortar, sewer pipe, and what not. The banks are perfectly solid to receive the additional weight coming on them. We will suppose we have yet to go about six feet in this loose or wet soil. We get 12-foot boards and cut in the middle, and chamfer to an edge one end of each piece. Now set a pair of stringers inside of the other curbing, the braces in line with those already in. These stringers must be good, sound pieces, not too

wide. These chamfered boards must be driven behind them, by placing a hard-wood block on them on end, and driving with a sledge down a little below the dirt in the trench. Lower the curbing, tight together, one man digging, others driving curbing, etc. As soon as this is down some distance, put another pair of stringers. Then dig and drive curbing, putting as many stringers as necessary.

Your chamfered boards may be generally trusted a foot below the lowest stringers, before the spring will bother you. All this may seem a great deal of work, and be very slow, but I have found to secure as you go is the truest economy in working in bad ground. In practice when good men get accustomed to it, and each man knows his place, one holds the stringer; another takes the sliding sticks, and measures for length of brace. The measure is passed to the top, the brace sawed, driven, and the work goes on. In this way, a few men will put in a good stretch of sewer in a day, while if your curbing is poorly managed, small cavings soon become large ones, and great quantities of earth thrown out that should be left in the bank. Every shovelful moved unnecessarily, does but increase the danger and tendency to cave.

Except the bracing stuff, and some splitting of the upright curbing, there is absolutely no waste of lumber. The same planks go from sewer to sewer, for months and even years, if they are not stolen. In the braces there is some waste, as they are split some in the driving, also in the fitting, as after repeated fittings, they get too short.

Here is the place to speak of pipe braces. These are made by filling each end of a piece of gas pipe of suitable length with an iron rod. On one of the ends is a screw and swivel, which squared up turns with a wrench. If it is desirable to move a brace, or set of braces, first secure the work with a new set, to take the strain from those you wish to move. This done, the others can be taken out without trouble. This moving has always to be done, whenever the piece of vertical curbing behind the ends of the brace is driven. The strain must be taken off by changing braces, at which time the piece behind the permanent brace may be lowered twice or thrice the usual depth. When the original or permanent line of braces is restored to place, the temporary ones are removed, and the digging is resumed.

As the less thumping and pounding done the better, extra effort is made to get down a good distance when the change is made. It is best, however, to take as few chances as possible; for if a cave begins ever so little, it is hard to stop. One brace loosens and falls out, then another, till the men get frightened, and won't go where they could do the most good. I have seen as much of a break-up in five minutes, as a large force of men could put right in three days.

I doubt if a very good job is ever done after a serious cave occurs. Having got to the depth of your curbing, and you want another six feet, the same thing is repeated, scaffolding is put in, and the earth thrown up from one to the other, till China is reached, if there is where you want to go; only proportion the strength of material used to the service you require. Now what we have already got, will be all that is necessary, till we come to the place which is the worst place you ever saw. This is a name always given, with stronger adjectives added, to every place where the water boils up with great force, where the workmen can't stand, and must have a device on the curbing to stand on, to keep them from being lost. In these places the sand and water will get through such small cracks it will begin to fill the tunnel of your finished work. Now Mr. Wiseman is on hand, and looks at it and swears he never saw anything like it, nor anybody else. He doesn't believe you will ever make a sewer worth anything. Why, he would n't work in the bottom of that sewer for all the earth and a mortgage on the moon. After disposing of Mr. Wiseman by death or otherwise, to prevent his scaring and discouraging your men, something else is necessary; and, gentlemen, when a place of this kind is struck, I know of no royal road out of it.

The presence of the engineer is of importance to encourage and hold every man to his work; with cool-headed confidence in your own ability, expedients of all or any kind, must be now in order. That sewer is going through, and you are going to do it. A good way after putting a board against the mouth of the sewer (this you no doubt have been using right along), is to get made a boiler iron box, by cutting the sheet a little wider than the sewer tunnel is deep, and of a length sufficient to allow it to be bent so as to form three sides of a square that encloses one of the sewer pipes, or if a brick sewer, then the length of a form, and a few inches to

spare. This is lowered, open end down stream. When down, the open end is kept apart by the completed sewer and a piece of plank two inches on each side for room, the closed end of the box being up the sewer. Now by using old rags, tufts of grass, etc., between the box sides and sewer, you have a tight thing, except the bottom, of a little more than the length of a pipe or form. This is settled till the sides are level with the top of the sewer. Now with the closing board at the sewer mouth, and the box on the other three sides, you are ready for a busy time to get in that section of the work. This done, and it may be quite a job,—but perseverance will do it,—the closing board is put at the mouth of the section just in. Now the box must be raised in such a way as not to injure the finished work. These boxes draw hard. Suitable holes have been left near the top of the box, to which we attach a heavy, strong chain. A long heavy lever with a block fulcrum generally brings it. For small sewers of course it is not so heavy, nor is the suction so bad. In all places of this kind that I have been in, this iron box has always helped me out.

Another thing I will mention. In some of those boiling springs, in spite of all I could do, the finished part of the sewer would get choked with the sand. In such cases I have made a dam a short distance in front of the tunnel, and built up something like a chimney as high as the water would allow. This gives a good head; and if done at night, we have found a clear passage in the morning. The progress through these places is so slow and discouraging I have been blue, but always felt like keeping on, and for the encouragement of younger men, who may meet similar difficulties, I have never had any of those places fail, either by settling or any other way, notwithstanding the cement would seem to cut away as fast as put on. Fortunately, these extremely bad places are scarce, and don't go many feet in any one place. I don't think I ever found 100 feet of such subterranean water-courses at one time, although a troublesome quicksand with lots of water is very common. Now I will leave this subject, lest I bore many who have been there so often, they don't want anything to do with, or hear about, them. Of sewers round, of sewers egg-shaped of sewers large, of sewers small; of systems combined, of systems divided, and of systems mixed, you have had a surfeit: and to add to the plethora, I will say about curbing, Keep the top all right, and

do n't neglect the bottom. The only pleasure I ever discovered in building sewers in quicksand was in getting them finished.

WM. APPLETON.

Prof. Davis. — Have you anything on substructure?

Mr. Appleton. — No; I purposely left all that out, as Latham's excellent work exhausted the subject, and should be in the hands of every sewer engineer.

Prof. Davis. — Well, gentlemen, I have listened with a great deal of interest to Mr. Appleton's experience with sewers in quicksand. Always keep the hole full. I had one job of a foundation in or on quicksand, where I put in the first course by putting the timber in place, and standing a lot of men on it with shovels and working the sand out from under it with their shovels; but I have found that I always accomplish what I start to do by keeping the hole full.

Mr. Hodgman. — Some years since, Prof. R. C. Carpenter, in a paper published, I think, in the *Rural New Yorker*, and perhaps also in the reports of the Board of Agriculture, illustrated the iron box and the method of using it in quicksand. He also called attention to the manner of handling quicksand with the shovel. He says that the shovel should not be worked about in the sand, but inserted carefully, and lifted directly out, the great point being to so use the shovel as not to move or disturb in any way the sand that is left. If this is carefully done, the sand will remain hard, and not run, while a slight disturbance will set the whole mass running.

THE THATCHER SPIRAL BOILER.

I HAVE taken this subject in the hope that my paper might create a discussion which will give something more than theory in regard to the type of steam generators that we shall take up.

Some months ago, through the kindness of a friend in Detroit, I had come into my possession the drawings of the so-called Spiral Boiler which was patented Nov. 6, 1888, by Lewis C. Thatcher, of Chicago. It consists of a series of hollow spirals constructed about a central core, and resembles in appearance an immense V threaded screw. The inventor proposes a double coil or a double threaded screw, claiming that that form recommends itself both for simplicity and for effectiveness of water and flue space. The flanges on the sheets forming the upper surfaces of the thread are turned down at the outer and up at the inner edge, while those on the bottom sheets are the reverse, so that the two sheets are connected directly to each other at the outer edges, and the top one to the lower one of the next spiral at the inner edges, thus forming the core.

The steam drum is added at the top, and by means of trussing inside this drum, the boiler is carried on the furnace walls which encircle it, so that entire freedom of expansion is allowed. A mud drum may of course be added at the bottom of the central core, if thought advisable. The top and bottom sheets of each spiral are stiffened by link stays inside. The man-hole is in the steam drum, and through this a man can be admitted to the core of the boiler, from whence he can reach with his hands every part of it. The furnace, the inventor proposes to divide, so that one half may be connected with each of the spirals. As to the necessity, advisability, or disadvantages of this, we are not prepared to express an opinion.

The inventor names as the objects aimed at and advantages of this boiler: —

First, The securing of a boiler wholly within the combustion chamber, whereby the loss of heat from radiation may be reduced to a minimum, and the rendering possible the use of the last available units of heat in the furnace gases to superheat, the steam; for it will be borne in mind that while the highest pressures yet in use in our boilers do not call for a temperature of over 350° Fahr. in the steam, the gases are almost never discharged to the chimney at a lower temperature than 500°.

Second, The exposing of the entire surface of the boiler to heat. This will not only increase the possible heating surface, but also will prevent unequal expansions and contractions with detrimental strains.

Third, A long and continuous fire flue. This insures a good draught with a great exposure of surface to the heat of the gases.

Fourth, A boiler free from obstructions in cleaning. This is an advantage that must be appreciated by all who have handled boilers.

Fifth, A form in which the line of disengagement of steam particles is freely upward.

On the other hand, one very serious objection to it would be the difficulty in its construction, for its surfaces are "warped," and hence cannot be developed on a plane; and so they could not be formed from plain sheets in the ordinary manner, but the sheets would probably have to be stamped into form while hot. It would also seem that this form of construction would require greater thickness of sheets than the ordinary for strength.

To consider the boiler as designed by the inventor more specifically, the central core is 2′ 6″ outside diameter, and the coils are 7′ 6″ outside diameter, which is the inside diameter of the furnace. There are two coils with a pitch of 24″. The space occupied by the lap between the two coils is 3″, which forms the shell of the core. The slope of the elements of the spirals is therefore 9″ in 30″, the bottom elements of the spiral being horizontal.

The projected horizontal breadth of the spiral is $\frac{7' 6'' - 2' 6''}{2} =$ 2′ 6″, and the mean diameter is 7′ 6″ — 2′ 6″ = 5′ 0″. The projected curve of the center of an element of the spiral will therefore be a circle whose diameter will be 5′ 0″, and its circumference very nearly 16′ 0″. Since during each rotation of the spiral every point

in the generating element rises 24″, the length of the path of the center of that element during a single resolution will be the hypothenuse of the right-angled triangle of which the circumference, 16′ 0″, is the base, and 24″ is the altitude, or 16⅔ feet nearly. The breadth of the bottom surface of the spiral being 2′ 6″, the area of the under surface will therefore be 40.3 square feet. The breadth of the top helicoid will be the hypothenuse of a right-angled triangle, of which 2′ 6″ is the base and 9″ the altitude, or 2.61 ft., and the area of the top for each turn will be 41.1 sq. ft.

The volume of each turn of the spiral will be equal to the area of the generating triangle. 9″x30″=270, sq. in. multiplied by the path of its center of gravity. The center of gravity of this triangle will be very nearly ⅓ of the distance from the short side, and the diameter of the circle of its projected path will be 2′ 6″+1′ 8″=4′ 2″, and the circumference will be nearly 154 inches, and the path of the center of gravity will be equal to the hypotenuse of a right triangle with this for its base and 24″ for its altitude, or 161 inches nearly. Hence the volume of one turn of one spiral will be 43.524 cubic inches. The surface of the core exposed for one turn would be equal to the product of its exposed width 3″, and the hypotenuse of a triangle whose base was twice the circumference of the core, and whose altitude was 24″, or 194 sq. in., and its volume would be 24″×742.6 sq. in.=17822 cu. in.

To determine the number of turns that are necessary, we must discover, if possible, the temperatures of the furnace and the chimney. Practical considerations with reference to draught, limit the temperature at which the gases shall be discharged from the furnace to not less than 500°, and 600° is really a closer approximation to ordinary practice. Assuming the temperature of our furnace to be 3000° Fahr., and referring to a table of the values of heating surface founded on Rankine's well-known formula $\frac{(ta-tb)^2}{a}$ $=q$, we find that starting with a temperature of 3000°, it would reduce to 570° at the 155th foot. We therefore should have 155′÷16.12′=9⅝ turns. Our total heating surface would therefore be, omitting the steam drum, of course,—

Top helical surfaces	42.1×19⅛=	813.9 sq. ft.
Bottom " "	40.3×19⅛=	779.1 " "
Core	194″×19⅛=	26.0 " "
Area of core in fire box = 94 × 24 = 2256″″ = say		16.0 " "
The total volume would be		1635.00 sq. feet.

Volume of spirals	48,524 cu. ins. × 19⅓ =	841,464 cu. ins.
" " core	17,822 " " × 10⅓ =	184,161 " "
		1,026,625 cu. ins., = 594 cu. ft.

So that for every cubic foot of water or steam in the boiler there is 2.75 sq. ft. of surface exposed to the heated gases.

As to the area and volume of the gas passages, they will be generated by the helical motion of a trapezoid whose parallel sides are 3″ and 12,″ and whose breadth perpendicular to these sides is 30.″ By a graphical construction we determine the center of gravity of the trapezoid to be about 18″ from the inner end or the core. The core being 30″ in diameter, the diameter of the circle of the projected path of this c. of g. will be 30″ + 36″ = 66,″ and the circumference will = 207.3.″ The path of the center of gravity will be equal in length to the hypotenuse of a right-angled triangle whose base is this circumference, and whose altitude is 24,″ which = 208.7″ per turn. The area of the trapezoid = $\frac{3+12}{2} \times 30 = 225$ sq. in. So the volume of one turn = 46,957.5 cu. in. = 27.17 cu. ft., and for 9¾ turns of each spiral the volume will be 27.17′ × 19½ = 525.29 cu. ft. Total area of gas passages = 3.7 sq. ft.

It is an established principle in boiler construction that the grate area should not be more than seven times the area of the gas passages. Taking an ordinary value for the ratio, we will make our grate area 6 × 3.7″ = 22.2 sq. ft. If the grate be situated 34″ below the bottom of spiral, allowing for a 10″ fire, the volume of the furnace would be 2′ × 22.2 sq. ft. = 44.4 cu. ft. Total volume of gas passages 44.4 cu. ft. + 525.29 cu. ft. = 569.29 cu. ft.

We therefore have, recapitulating,—

Total grate area,	22.2	sq. ft.
" heating surface,	1635.00	" "
" volume of water and steam independent of drum,	594.00	cu. ft.
" " of gas passages,	569.30	" "
Ratio of heating to grate surface,	73.65	
" " " surface to contents of boiler,	2.75	
" " " " " " " gas passages.	2.87	

For purposes of comparison, we will find the same data in an ordinary horizontal tubular boiler, 5′ 6″ diameter of shell, 14′ 0″ long having 82 — 3½″ tubes, and set with a calorimeter 30″ high at the lowest point. We find —

Total grate area = ⅛ of tube area,	33	sq. ft.
" heating surface, including both front and back,	1285	" "
" volume of interior of boiler,	255.92	cu. ft.
" " " gas spaces,	417	" "
Ratio of heating to grate surface,	39	
" " " surface to volume of interior,	3.6	
" " " " " " " gas,	3.1	

First, considering the question of grate area: From experiments made upon a marine boiler at the Brooklyn Navy Yard, as well as from many others, we discover that reducing the grate area, and burning the same amount of coal per foot of grate, increases the efficiency of the boiler.

D. K. Clark is authority for the statement that the performance of a boiler, other things remaining constant, increases as the square of the heating surface.

So far the advantage seems to be with the Spiral Boiler, but when we come to a consideration of the ratio of the surface of the water exposed, to the volume of the water, the tubular boiler has a decided advantage, as for every cubic foot of water it contains it exposes 3.6 sq. ft. of surface to the heat, while the Spiral Boiler only exposes 2.75 sq. ft. So also for every cubic foot of gas generated, the tubular boiler exposes 3.1 sq. ft. of surface, while the Spiral Boiler exposes only 2.87 sq. ft.

But the form of the gas passages are such, we think, as to overcome partially this disadvantage. On account of the spiral form of these passages, the gases would be caused to whirl and rotate while passing along, thus bringing every particle of gas into contact with the plates, and mixing thoroughly the gases with the air. This latter is a very important point, for while the percentage of loss of heat by radiation and stoking can be reduced to almost nothing, there is a certain amount of heat that must be carried up the chimney by every pound of air, so that if more air be admitted than is absolutely necessary for the combustion of the fuel, it causes a dead loss of heat, for it all has to be raised to the temperature of the discharged gases, and the heat so used is of no further avail. It is further to be noted that in Isherwood's experiments when with a consumption of 16.57 lbs. of coal per foot of grate he got an evaporation of 7.94 lbs. of water per pound of coal with his whole heating surface; when he cut out his tube surface, which amounted to 70 per cent of his total heating surface, he got an evaporation of 5.91 lbs. of water per pound of coal or of 74½ per cent as great. This

shows that it is essential to bring the flame itself into connection with the boiler plates as much as possible, and for this purpose the spiral boiler is especially adapted.

In the Spiral Boiler the exposed surface of that portion of the gas passages which would contain flame, is much greater in proportion to the volume than in the case of an externally fired tubular boiler.

Theoretically for the combustion of 1 lb. of carbon, only 12 lbs. of air must be consumed; but in practice it is found that many boilers require 25 lbs. of air per pound of carbon. There are boilers, however, that work on only 15 lbs., and as the amount of air required is largely due to the intimacy with which it is mixed with the particles of gas, it would seem that the Spiral Boiler should have a very low requirement. Moreover, this same question of intimate mixing of gases and air is at the basis of the prevention of smoke. The appearance of smoke is an evidence of a waste of fuel, and if the products of combustion are properly mixed with a proper supply of oxygen, it should not appear.

Let us now figure theoretically the possible efficiency of a boiler: —

If we assume that we discharge the products of combustion into the chimney at a temperature of 600° Fahr., and that it requires 15 lbs. of air for every 1 lb. of coal burnt, there must go to waste an amount of heat determined as follows:—

The products of combustion of one pound of coal and 15 lbs. of air will be 3⅞ lbs. of C. O_2., ⅞ lb. of O., and 11⅞ lbs. of N. Multiplying by the specific heats, we have —

C. O_2.	$3.7 \times .217 =$	.8029 *H. U.*
O.	$.7 \times 2.18 =$	1.526
N.	$11.7 \times .244 =$	2.855
Total,		5.184 *H. U.*

which is the amount of heat necessary to raise the temperature of the discharged gases 1° Fahr. Now if the gases are discharged at 600°, and the air was admitted at 60°, the total heat required to be wasted will be (600° — 60°) + 5.184 *H. U.* = 2799.36 *H. U.*

A pound of coal will generate 14,500 H. U., so on our supposition there is left available 14,500 H. U. — 2799.36 H. U. or 11701 H. U. or 80$\frac{7}{10}$ per cent efficiency is possible. In order to increase this efficiency, we must either decrease the quantity of air required, or we must discharge the gases at a lower temperature than that as-

sumed above. The two things working together for the object of discharging the gases at this temperature is primarily to obtain the requisite draught, and the more air required, the greater must be the draught, and the hotter the discharged gases. Then, too, if we compare the Spiral Boiler with one of the old type having the same heating surface, it will be seen that the friction and losses of heat due to contractions and enlargements must be appreciably greater in the old type than in the spiral, and hence the Spiral Boiler will require less draught than a boiler of equal capacity of the older types. It, therefore, seems that this boiler should be a very economical one, and we should feel like giving it our indorsement were it not for a few other points that must be considered later.

This boiler has another advantage over the horizontal tubular or any horizontal boiler; viz., the small floor space required, as for the present boiler of about 100 H. P., allowing 16″ walls for the furnace, only a circle 10′ 0″ in diameter would be required of floor space, but the hight would be about 28 ft., including the steam drum.

Among the points which must be carefully considered, is that of circulation, and the conditions that are likely to exist on the extreme edges of the spiral, also whether the pitches given for the spiral and for the surface of the upper helicoid are sufficiently great to allow of a free disengagement of the steam particles, as the inventor claims. This is one of the points upon which we must rely upon experience, as also in the question of the ease of entry of the cooler water to the spiral portions, to replace the steam as generated. Then there further comes in the question of stays as to the number and position and the obstructions they must offer to cleaning, and to the liberation of the steam particles. The above, with the subject before referred to of the difficulties of construction on account of the warped surfaces involved, must be the ones that will control the future success of this type of boiler.

G. S. Williams.

WHO OWNS THE LAKE BEDS?

THIS is a question of a great deal of interest to the owners of lots made fractional by small lakes within the regions subdivided by the United States Survey. It has been debated pro and con for many years, and in at least one case a State has been at law about it.

There are two questions in relation to these lake beds which are of interest to surveyors.

1. The primary question already mentioned, who owns them?
2. How are the boundaries between owners to be determined?

As to the first question, it is pretty certain that these lake beds belong either to the United States, to the State, or to the riparian owners around the lake. One view which seems to differ from the generally accepted views on these points, is held by the Supreme Courts of Michigan and Indiana.

In Klute *vs.* Fisher (31 N. W. Rep. 614) the Michigan Court says: "The true and only rule is to invest the holder of the title of any fractional subdivision of a section bordering on a lake with the ownership of the bed of the lake to the lines of said subdivision, *as they would be if continued through or into the lake.*"

More recently the Supreme Court of Indiana has ruled (Stoner *vs* Rice, 22 N. E. Rep. 968) that "when an inland non-navigable lake covers a portion of a section of land, and the government survey designates the dry land in each subdivision as a fraction or a lot, the purchaser from government of such lots acquires title to *all that portion of the bed of the lake included in the whole subdivision.*"

The principles thus laid down would work very nicely in a great many cases, and the riparian owner and surveyers would have plain, easy sailing till they happened to come across one of the many cases where these principles would not fit. I will comment on these decisions further on. On the other hand, while it is universally conceded that the bed of a lake which was not meandered by the United States Survey belongs to the owners of

the adjacent shore, it has not been generally so conceded for the bed of a meandered lake. The land department of the United States, so far as I can learn, has never conceded that their conveyances of fractional lots carry the beds of the lakes with them. Up to 1877, they made regulations by which the beds of meandered lakes becoming dry by natural causes, might be surveyed and sold, and many of them were surveyed and sold accordingly. Since that time they have refused to survey and sell such lake beds except in a case where it was shown that the original returns were fraudulent, and that in fact there never was a lake where the official plot and field notes represented one to be. This refusal to survey and sell such lake beds, has been placed on the ground that there was no law authorizing the survey and disposal of meandered lakes. Secretary Lamar adds in a ruling, July 12, 1887: "Besides, I am not satisfied that the bed of this lake does not inure to the owners of the adjacent tracts upon the principle of accretion as ruled in Boorman *vs.* Sunnuchs (42 Wis. 233), and in Forsyth *vs.* Smale (7 Bissell 201)." It was concerning such lakes that Judge T. M. Cooley said: "There are many lakes and ponds which are gradually disappearing, and the shore proprietorship advances *pari passu* as the waters recede." But it could not so advance nor could the bed of the lake inure to the shore proprietors on the principle of accretion, if they owned it as ruled in Klute *vs.* Fisher and Stoner *vs.* Rice.

In Forsyth *vs.* Smale it is ruled that "the grant includes any land between the meander line and the water in an unnavigable stream, and that the same principle applies to unnavigable lakes." In Wisconsin it is ruled in Boorman *vs.* Sunnuchs and Deidrich *vs.* N. W. U. Ry. Co. (42 Wis. 271), that the riparian owner upon a natural lake or pond takes only to the natural shore, and that the boundary lines should be extended according to the rule for accretions in navigable waters.

In Eversen *vs.* City of Waseca (46 N. W., Rep. 405), the Supreme Court of Minnesota ruled that a patent from the United States of a surveyed subdivision bounded on a meandered lake, conveys the land *to* the lake. In the case of the State of Indiana *vs.* Milk, in which the ownership of the bed of Beaver Lake was at issue, Judge Gresham cites numerous authorities to the effect that "a grant to a natural pond or lake extends only to the water's

edge," and adds: "By their purchase of the abutting tracts, Dunn & Condit acquired title to the water's edge, and no further."

The writ of authority seems to be clearly against the abutting proprietors having any title to land under the waters of meandered lakes. It must then belong either to the State or the United States.

It has been ruled by the Supreme Court of the United States in County of St. Clair *vs.* Livingston, that "the United States never had any title to land under the navigable streams and lakes." This is on the ground that in the original cessions to the United States they were expressly reserved for use as public highways. In such a case, the title would be in the State. It would be interesting to know how far that decision reaches, and how we are to distinguish between a navigable lake and one not so.

What is to determine the question? Is it size, length, depth, either or all combined? and, if so, what is the size, length, and depth required to make navigable lakes of them, and place the title in the State? Many of our small lakes are navigated by boats of large size, and many more might be. Steamers of as great draft, as those navigating many of our rivers, carry pleasure parties from place to place, and tugs haul rafts of logs and scow-loads of wood along their surface. If the same rules of law which the United States Courts apply to streams apply also to lakes to determine whether or not they are navigable, then a goodly proportion of our meandered lakes are also navigable lakes, and the United States having never had any title to them, could not convey any title to their beds by the sale of the abutting tracts.

It would seem, then, that we have three classes of lakes,—

1. The unmeandered lakes which are bought and paid for the same as the dry land by the purchasers of the abutting tracts, and of course owned by them.

2. The great lakes and so many of the smaller lakes as may be determined to be navigable, in which the beds are owned by the State.

3. Unnavigable meandered lakes in which the title is in the United States.

In the first class, it is believed the public have no rights whatever. In the second and third classes, they have rights of fishery, ice-cutting, etc., which may be and are regulated by public authority.

We now come to the question of how the boundary lines shall be extended or located in the lake beds. The answer depends almost entirely on the question of title. If the title of the abutting owners stops at the water's edge, as held in the cases cited, in case the water recedes, the boundary line will be extended according to the laws governing accretions, which are supposed to be familiar to the members of this Society. (See Manual of Land Surveying, Fifth Ed., p. 279.)

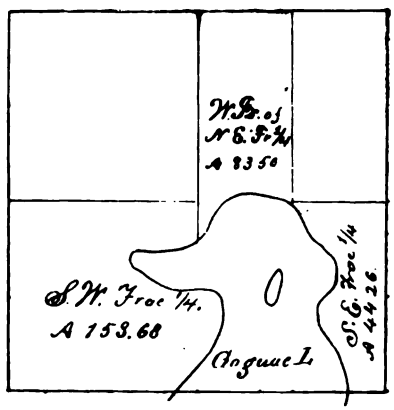
If, on the contrary, the abutting owners own the lake beds also in the manner held in Klute *vs.* Fisher and Stoner *vs.* Rice, then the boundary lines are to be located on the same principle as if there was no water there. This view of the case does not seem to me to be sound or just, as a general principle or rule, while at the same time in many cases it would be a very convenient rule, and do no special harm; but,—

1. The government did not sell the land that way. It has never been conceded by the land department that they sold the land under the waters of meandered lakes. When the lake is not meandered, they sell it, and charge the purchaser the same price per acre that they do for the upland. Would it be just to make one man pay for a lake which is not meandered, and give to another man for nothing the lake that is meandered? It was not so intended.

2. There are hundreds if not thousands of cases in which this Michigan and Indiana rule cannot be enforced without disturbing vested rights which have been thoroughly settled by the courts. There are fifty or more such cases in my own county alone. The act of 1820 (R. S. 2397) provides that fractional sections shall be subdivided into quarter-quarter sections under such rules as may be prescribed by the Secretary of the Interior. Under that statute, the Secretary of the Interior prescribed rules directing that such sections be divided by north and south or east and west lines, so as to preserve the most compact and convenient forms. It has been definitely settled that these rules were valid and lawful. (See Gazzam *vs.* Phillips lessee 20, Howard 372.) Under these rules it has been the custom of the land department ever since to divide these sections so as to preserve compact and convenient forms. In doing so, they have frequently attached small outlying fractional lots to an adjoining larger tract, and sold the whole by a description derived from the larger tract. These

outlying fractions have not always been in the same section, or even in the same township, as the tract with which and by name of which they were sold.

Take, for instance, Section 14 in the township of Battle Creek, Mich. The cut gives a correct idea of the official plat of that section, and the manner in which it was sold. Goguac Lake lies partly in the section, and has an island lying wholly in the south-east quarter. This island was meandered and sold by itself, and has ever since been occupied by the grantees who derived title from the United States Government. There is a tract of several acres lying west of the lake and east of the north and south quarter-line which is entirely separated by the lake from the rest of the south-east quarter. It was attached to and sold as a part of the south-west fractional quarter. The north and south quarter-line was not extended across this tract on the official plat of this section. There is another small tract in the south-east quarter, but entirely cut off from the rest of that quarter by the lake. It was attached to and sold as a part of the west fractional half of the north-east quarter. The remaining tract lying east of the lake was sold as the southeast fractional quarter. Now suppose we attempt to apply this new Michigan-Indiana rule to this case, and see how it works. If as in Stoner *vs* Rice, the purchaser of the southeast fractional quarter is entitled to the entire quarter section, he must take away the island from one man, and the tract north of the lake from another, and the tract west of the lake from another, in order to get what belongs to him. But the Supreme Court of the United States (Gazzam *vs.* Phillip lessee) says that cannot be done, and the Supreme Court of Michigan too (Wilson *vs.* Hoffman, 38 N. W. Rep. 558), says that cannot be done. Then what becomes of the principle laid down in Stoner *vs.* Rice? and how are we to determine the boundaries of the island and these outlying fractions on the principles laid down in Klute *vs* Fisher? That cannot be



done either. The only way such cases can be rightly adjusted, is on the grounds that the owners of the abutting tracts do not own the bed of the lake. But it may be said, This is an exceptional case. Not so; on the contrary, it is a very common case. The township of Ross alone, in Kalamazoo county, has sixteen tracts of land similarly situated.

Lastly, we may refer to the official plats of the government survey as having some bearing on these questions: "Lands are not surveyed lands by the United States until a certified copy of the official plat has been filed in the local land office." (United States *vs.* Curtner, 38 Federal Rep. 1.) This official plat defines the location and boundaries of the various tracts into which the section is subdivided. In Gazzam *vs.* Phillips lessee, the Court tells us the sales to Stone and Etheridge "were in conformity with the official plat then on file in the local land office." It determined the extent of their grants. This is the regular course in all government sales of the public lands. Now I find in all the official plats that I have examined, and I assume that it is the same with most if not all of them, that *no part of a meandered lake is included within the marked boundaries of the abutting tract*, and hence is not included in the sales of those tracts. On the official plats, neither township, section, nor any subdivision lines are extended across these lakes. They are entirely segregated from the surrounding tracts.

Resume: From these considerations, I think we may conclude that it is fairly well established, where the United States Survey extends,—

1. That the beds of non-meandered lakes belong to the owners of the adjoining land, and the boundaries are found the same as if no lake were there.

2. That the beds of navigable lakes belong to the State.

3. That the beds of meandered non-navigable lakes belong to the general government.

4. That in the second and third cases above, the proprietors of the adjoining lands own to the water's edge, and in case the water recedes, their boundary lines will be extended in accordance with the laws governing accretions. (Since the above was in type, I have received a copy of the ruling of the Secretary of the Interior, April 29, 1891, in the case of Popple and others, in which the matter is fully considered, and it is held that the bed of Crab Lake, a meandered lake, belongs to the general government.)

F. HODGMAN.

NOTES ON ENGINEERING IN NICARAGUA.

In February, 1881, I was called to take a position as transitman with Frank P. Davis in a party engaged in the location of what is now the Denver & Rio Grand Western Railroad in Utah. A young man of Climax, named E. U. Hunt, decided on an hour's notice to go with me, and take his chances of getting work when he arrived there. He had a fair common-school education, and had been at work by the month on a farm, and saved his money till he had enough to pay his expenses to Salt Lake City, and some besides. He was assigned to our party, and I put him at the head of the chain. He put in all his spare time in learning the use of instruments, how to run curves, etc. It was not long till he was competent to do anything we had to do on the line. In a short time I was assigned to a party of my own. Hunt staid with Davis, who gave him plenty of opportunity to advance. Before the end of a year, Davis was resident engineer in charge of all the work from Green River to Clear Creek, about 200 miles, and Hunt had done nearly everything from chaining to track laying. In March, 1882, that job ended. I came home. Davis went in charge of a locating party in the Rocky Mountain Division of the Canadian Pacific, and Hunt went with him. They staid there two years, Hunt as transitman the last year. Then Davis returned to his home in Washington, and Hunt invested his spare cash in a Kansas farm.

When the Nicaragua Canal was ready for a survey, Davis got a position on the engineering staff, and sent for Hunt, who accompanied him there. He is now at his old home in Climax, on a vacation, and I jot down a few of the odds and ends that I have picked up in conversation with him. The party sailed from New York, October 28, 1887. At Jamaica they took on about 100 negroes for workmen. They had about nine months' supplies with them. They reached Greytown early in November, and went up the San Juan River by boat about forty miles to an island on

which they established a permanent camp. The canes were so thick here that they were obliged to cut them before they could land.

About the first thing on landing, the darkies found a big tobova five feet long, which scared them so that it was at least half an hour before they could be induced to go to work. The tobova is a poisonous snake something like a rattlesnake, with immense fangs an inch to an inch and a half long. The poison passes down the inside of the fang, and is ejected from a small hole near the point. Its bite is sure death. Fortunately, it is a very sluggish serpent, and not at all aggressive, never seeking a quarrel. For a month Hunt had charge of the work on the island, putting up offices, store-houses, tents, and all the necessaries for a permanent camp.

In the meantime, Davis went up the river five miles to begin the survey. His party went in small steel boats, of which the company had a number. The river was so full of logs and snags that it took them five days to go the five miles. This camp on the island was for the headquarters, from which the different parties were to receive supplies and orders. The San Juan River rises in Lake Nicaragua, and empties into the Caribbean Sea at Greytown, running 120 miles to get sixty-five on a straight line. It is from 1,000 to 1,500 feet wide. In going up the river the first four or five miles, the banks are low and swampy, and covered with a dense growth of vines and silico palms.

Further up the river, the banks are higher, and covered with large trees and wild cane. At twenty miles are quite large hills, spurs from an interior mountain range. At forty miles by river is Camp Carejo, on the island before mentioned. Forty miles further on at the foot of Castillo Rapids, is the old Spanish Fort Castillo, where Walker tried to take Nicaragua. The ruins of the fort are there yet, with a few bare-footed soldiers to guard them. Forty miles further is the lake, a sheet of fresh water about forty by ninety miles in extent. Two mountainous islands rise out of the lake to a hight of over 5,000; one of them was an active volcano for several years, and only went out a short time before the party arrived there. The lake and river are full of fish, sharks, and alligators. From the west side of the lake to the ocean is only seventeen miles of rocky volcanic soil, having five to sixteen feet of black loam on top, and disintegrated rock below.

The upper 65 miles of the river is to be slack-water navigation. To effect this, a dam 52 feet high and 1,000 feet long is to be thrown across the river. It is to be a rock-fill dam, the material for which is to come from the big cut in the divide, about 12 miles away, from which it is to be brought by rail. One of the jobs to which Hunt was assigned was to make borings for the dam. For this purpose he was furnished with a derrick and augers, and negroes to run them. About the first thing he did, was to dispense with the derrick, get a pair of climbers, and attach his head block and tackle to the trees above. This was a great saving in time and labor, as there was no moving of derrick to be done.

He also made borings the whole length of the canal line. These were carried down to the grade line of the canal, or to rock. Dif ferent sized augers, from 1½ to 4 inches, were furnished him. The 2½ inch worked very much the best, and was about the only one he used. Along the beach it was impossible to bore in the sand, and he procured a pipe and point, the same as are used in drive wells, and explored the earth with that. The same apparatus was used in the harbor, and the pipe driven from a platform laid across two boats. When he went to make the borings on the west side, he was furnished with an interpreter, and got his help from the natives. These all spoke Spanish, and Hunt and his interpreter were the only English speaking men in that part of the country. Hunt per force learned Spanish, and it was not long till he could understand it, although he had not the language at command to speak it himself to any great extent.

The men were bright, active, and willing, and very much preferred receiving their orders direct to getting them through the interpreter, and it was not long till they were able to dispense with his services. When the men got a few words of directions, they were quick to "catch on" to the rest. On the east side, things were different. The negroes spoke English, and had to be watched and directed all the time. Another piece of work intrusted to Hunt was running the flowage line along the Chanchos River, a tributary of the San Juan emptying into the latter above the dam. This was simply tracing the 106-foot contour; but owing to the character of the country, which is cut up with small streams and ravines, and covered with a dense growth of trees and undergrowth, it was a difficult and trying job. The line would frequently make a long sweep, and return within a few feet of itself.

At another time Hunt had charge of a locating party, locating the line of the railroad from the dam down. This railroad line follows the canal, and is practically the key to the whole work. At the divide there is a rock cut, averaging about 200 feet deep for three miles; a single short pinnacle runs up 325 feet. The main work on the canal lies in that cut. All the rest of it can easily be done quicker than that one cut can. The rock must be taken out of the cut, and put into the dam a dozen miles away, and the railroad must be built to carry it there. Up to the present time, less than a dozen miles at the lower end have been built.

As may be supposed, the location of the railroad line was no easy task. The ground was so rough, and the vegetation so thick, that every foot of the ground had to be gone over. One might be within ten feet of a good-sized hill, and not know it. Preliminary lines were run, and then at every 200 feet, cross sections were run out each way, and leveled. A map was then made showing 10-foot contours of the strip. The location was then made on the map, and afterward reproduced on the ground. It was found here, as it has been elsewhere, that the first cost of a road on a tangent through an obstacle, is frequently less than on a curve around it. The stakes used were round sticks cut on the ground as wanted. They were not driven, but pushed down by hand in the wet clay soil as deep as needed. They frequently sprouted and grew. The machete was about the only tool used in cutting brush and opening the line. In fact, the natives use it for almost everything, from cultivating their gardens to smiting their enemies. It is a heavy knife two feet long and two inches wide. It is wielded in one hand, and saplings as large as a man's arm are sometimes cut at a single blow with it.

One trouble the parties had to contend with was the rain. During the rainy season it rains about all the time, and work must be done in the rain if it is done at all. Out of doors everything is soaked. Inside everything is damp and moldy. Everything rusts that can rust. Books fall to pieces. Everything falls apart that is put together with paste or glue. For rain and mud, Nicaragua "takes the cake." At Camp Carejo the rainfall in January, 1888, was 30 inches, in July 34 inches. Total for the year, 19 feet, 6 inches. There is no doubt as to where water is coming from to fill the canal. The climate is not excessively hot, but enervating. A two-mile walk exhausts a man. Hunt says that many a day

after working in the thickets or swamp up to his arms in water all day long, he would come in all used up, and ready to sink the whole country out of sight if he could. Then he would take a bath, change his clothes, and lie down; and in a little while he would feel as fresh as a lark, and ready to swear there never was so delightful a climate as in Nicaragua. He has been there since 1887, with the exception of two short vacations, and has not been sick in bed a day, and there has been but very little sickness among the employees of the company — no more than is usual in the States.

A little over a year ago Messrs. Perry and Hunt made a re-location of the canal line through the divide. They were the only white men in the party, and had all the instrument work to do. A strip of land 1,000 feet wide was cross-sectioned every 200 feet. They did not succeed in shortening the line any, but saved half a mile of 200-foot rock cut. This work was completed in March, 1890. Hunt was then assigned to work on the harbor improvement at Greytown, and put in charge of the work on the jetty. The prevailing direction of the waves here is such that they strike the shore at an angle, which keeps the sand constantly moving along the coast in one direction. This driving of the sand along the coast has filled up the mouth of the harbor. A jetty is being run out to stop it. This has had a double effect — stopping the moving sand on the one side, which piles up against and strengthens the jetty, while on the other side the incoming waves carry the sand away, thus helping to open the harbor, which before they had closed.

The jetty is made of a double row of piles 35 to 50 feet long, and fastened together at the top by caps 14″x 14″x 42′ drift bolted with 1¼″ bolts. Four pile-drivers having 2,800-pound hammers were used. The piles and caps were all creosoted at the rate of 16 pounds of creosote to the cubic foot. They are very heavy to handle. A nail driven into one of them stays there. It can't be pulled. In getting them into place, a track was laid along the jetty as fast as it was built. Nothing better being procurable for a conveyance, the bodies were taken off from some dump cars, and a long reach made of a pole was put between the wheels, and the timbers run out on these extemporized logging cars. In putting the caps into place, two of the pile-drivers were utilized. Cables from them were attached to each

end of the cap, when it was raised and swung into place with little effort. The first piles on the beach were driven with hammers. All the piles were driven 20 feet into the ground. As they went out into the water, it became more difficult to drive them. The piles would break, and curiously enough, they always broke at the surface of the water. A steam pump had been provided, and Mr. Menocal recommended that Mr. Hunt try the water jet. Hunt replied that he knew nothing about it. He never saw one. Neither had Mr. Menocal. There was not a man in the place who had ever seen a pile driven by a water jet.

Experiments were in order, and at it they went. An iron pipe as long as the pile was attached to it. Hose from the steam pump was attached to the top of the pipe, and a brass fire nozzle to the bottom. It did not work. First it had to be bent so as to throw the stream directly under the bottom of the pile. Then the hole was not big enough. A larger one was tried which was an improvement, but not a success. Then Hunt had a point made by drawing down a piece of the tubing, and put that on. It worked all right. Then they had trouble in keeping the tube in place on the pile. That was solved by running it through a staple at the bottom of the pile and another at the top, with chains wound around the top of the pile, and fastened with staples. They were not long in learning that the water jet must be started before it reached the ground, and kept going till the pile was down. Otherwise it would not start at all, and the water was sure to find a vent somewhere, generally by bursting the hose or breaking the connection with the pipe. In driving the pile it was brought to place in the pile-driver, and connection made with the pump. Then the jet was got under good motion, the hammer let down with its weight resting on the pile, and down it went. The hammer kept the head of the pile in place, and helped to push it down. When it was down far enough, the tube was pulled out, and the pile given a few raps with the hammer by way of emphasis. Brush mats were put in back of the piles, and dredges inside hoisted the sand out of the harbor, and deposited it back of the jetty. F. H.

LEGAL DECISIONS.

THE following decisions of interest to surveyors are from the law reports published by the West Publishing Co., of St. Paul, Minn.: —

1. The written explanation accompanying a plat stated that it was a plat of certain land "in blocks or squares by the drawing of lines across said ground where the center line of the street will come when the same is platted to correspond with the C. plat and the streets in this plat; it being the intention to plat said grounds, or in the event of their being sold to provide for their being platted, to correspond with contiguous ground already platted." *Held*, that this did not constitute a dedication of land for streets between the blocks.— *City of New Albany vs. Williams* (*Ind.*), 25 N. E. 187.

2. Persons who had dedicated to public use a certain strip of land known as "Park Place," running through the center of a street, with highways on either side, agreed in writing to relinquish all their reversionary rights in said land, upon the condition that a street be constructed through it, and that the title in the highways vest in the abutting lot-owners. The written instrument described the land first as "Park Place," and then again as a "strip of land lying in the center of a street running east and west between First and Brook streets," but Park Place extended beyond Brook street. *Held*, that they thereby relinquished all their rights to the whole of Park Place, and that the title in the highways along the land, including those portions beyond Brook street, vested in the abutting lot owners. — *Allen vs. Reinhardt* (*Ky.*), 14 S. W. 420.

3. Where the title of the public to a highway rests upon both dedication and prescription, and the evidence tends to support the title on either ground, the act of the dedicator in building a barbed-wire fence in the limits of the road, after many years of adverse use by the public, cannot be given weight as an act indicative of an intention to revoke the dedication already ripened into title. — *Bartlett vs. Beardmore* (*Wis.*), 46 N. W. 494.

4. A deed described the land conveyed as beginning at a certain rock, and running thence one mile east, one mile north, one mile west, and one mile south, to place of beginning; and also stated that it was the land set off to a certain Indian under a treaty with the government. The Indian had previously selected his land as "a tract one mile square, the exact boundaries of which may be defined when the surveys are made." After the deed was given, the Indian's land was located and patented so as to include 640 acres not in the form of a square, no part of which lay within the boundaries named in said deed. *Held*, that the deed, being for a specific tract of land, could not be construed to convey the grantor's interest in the land actually patented to the Indian.— *Prentice vs. Northern Pac. R. Co.*, 43 *F.* 270.

5. In a suit to quiet title, a deed was offered in evidence in which the land was "bounded and particularly described as follows, to wit: On the N., 240 feet on Mill street; on the E., 110 feet on a 30-foot alley; on the S., 240 feet on an alley; on the W., 110 feet by a 30-foot alley; and being all of lot Nos. 1, 2, 3, and 4, all of block No. 8, as per plat of Johnson & Murry's addition to the town of P.; being all of said block No. 8 in said addition to P., Tulare county, Cal." Counsel offering to follow it with a plat of the addition referred to, *held*, that an objection to the deed because it described nothing, was properly overruled.— *Redd vs. Murry* (*Cal.*), 24 *P.* 841.

6. A deed having described the land by reference to the plat of an addition to a town, an unrecorded plat is, as against the grantor and his privies, *prima-facie* identified as the one referred to, by evidence that he afterwards exhibited it as the plat of the addition.— *Redd vs. Murry* (*Cal.*), 24 *P.* 841.

7. A deed having described the land conveyed by reference to the plat of an addition to a town, parol evidence is competent to locate the land granted from *data* given in the plat, and it is not necessary as against the grantor to show that there was an actual survey of the addition.— *Redd vs. Murry* (*Cal.*), 24 *P.* 841.

8. A deed described the boundary of the land conveyed as running to a certain creek, and "thence up the creek at high-water line in a north-easterly direction, the bearing is about north, 86° east." The creek ran south-westerly, but not at the angle named. *Held*, that the creek, being a natural monument, controlled the

course, and formed the boundary. Following Caspar *vs.* Jamison, 21 *N. E.* 743.— *Shepherd vs. Nave* (*Ind.*), 25 *N. E.* 220.

9. A deed of land bordering on a non-navigable lake or pond, commencing at a known monument on the shore of the pond, and running thence "along said pond to the outlet thereof," conveys only the land to low-water mark, and not to the center of the pond. Disapproving Ledyard *vs.* Ten Eyck, 36 Barb. 125.— *Gouverneur vs. National Ice Co.*, 11 *N. Y. S.* 87.

10. Where a patent describes a line as beginning at a corner on a branch and running "up the branch and binding thereon," the line must follow the water-course, and not the courses and distances as found by survey.—*Bailey vs. McConnell* (*Ky.*), 14 *S. W.* 337.

11. A deed of lots according to a plat on which the lots are bounded on one side by an alley, passes title to the center of the alley, where the grantor's title extends thereto. Following Schneider *vs.* Jacob, 5 S. W. 350.—*Jacob vs. Woolfolk* (*Ky.*), 14 *S. W.* 415.

12. For over twenty-five years a fence had stood between plaintiff's and defendant's lots. The owners of the lots had always thought that the fence was in the right place, and on the line. When the fence was originally built, or under what circumstances, did not appear. The only change made in the fence was that eight years prior to defendant's tearing it down, a new fence had been built in place of the old, which had, by direction of the then owner of defendant's lot, been placed three inches further thereon than the old fence. *Held*, in ejectment, that the owners of the lots having acquiesced in the line of the old fence for over twenty years, defendant was precluded from asserting that it was not the true line.— *O'Donnell vs. Penney* (*R. I.*), 20 *A.* 305.

13. Where land is described as bounded by the center line of a street extended, and the street has never been opened or dedicated adjoining such land, the mention of the street does not amount to a dedication.— *Sanford vs. City of Covington* (*Ky.*), 14 *S. W.* 497.

14. Where the owner of an entire tract has it surveyed and laid off into lots and streets, and a map made of the survey, and then sells the lots at auction before the map is filed for record, but does not deliver the deeds until after it is recorded, there is a complete dedication to the public of the streets designated on the map, and a purchaser at the auction sale at which the map was

used to inform purchasers of the location of the lots and streets cannot close the street, though his deed includes the land to its center, for that is simply a conveyance of the legal title subject to the public easement.— *Griffiths vs. Galindo* (*Cal.*), 24 *P.* 1025.

15. Where in a platted block the lots are marked on the plat as having the same number of front feet each, except one, the specific dimensions of which are also marked, and a survey shows that the whole block contains more front feet than are marked on the plat, the excess must be distributed between all the lots, and not given to that lot only which differed in its dimensions from the rest.— *Pereles vs. Magoon* (*Wis.*), 46 *N. W.* 1047.

16. Plaintiff conveyed part of a tract of land, separated from his other land by a road. He built a fence along his side of the road, and maintained it for nearly thirty years. He then attempted to move his fence nearer the land sold, claiming that the old fence did not correctly mark the boundary of the road. The evidence was conflicting. *Held*, that plaintiff was bound by the line as marked by his first fence.— *Sherman vs. Hastings* (*Iowa*), 46 *N. W.* 1084.

17. Where the description of land calls for another survey on the west and for a chestnut-tree as its south-west corner, and the adjoining corner of such other tract is described in its survey as being a fixed distance from a third survey lying on the west, it is a question for the jury whether this last point, or a chestnut stump further west, claimed to be the original monument, is the true corner.— *Bushey vs. South Mountain M. & I. Co.* (*Pa.*), 20 *A.* 549.

18. The dispute as to a boundary was as to the location of a quarter-section corner according to the original government survey. The commissioner reported that it was in the center of the section line, which was the point at which such corners were usually established, and which would give to the owners of each quarter section the same amount of land. The field-notes of the government survey, made in 1851, called for two burr-oak trees of a specified diameter, at specified distances from the quarter-section corner; and the commissioner reported that he found the stumps of two burr-oaks by measuring the specified distances from the center of the section line. *Held*, that it was error to set aside the commissioner's report, and to enter judgment to the effect that the quarter-section corner is located at a point 20 rods west of the center of the section line, though two burr-oaks bearing certain marks stand in

substantially the position called for in the field-notes measuring from that point; the testimony being conflicting as to character of the marks and the diameters of these trees in 1851, as shown by their present diameters.— *Yocum vs. Haskins* (*Iowa*), 46 *N. W.* 1065.

19. Under Acts 15th Gen. Assem. Iowa, c. 8, permitting a commissioner to be appointed by the district court to survey and establish disputed boundaries between parties, it is competent for the court to appoint such a commissioner on plaintiff's application, even though defendant claims title by prescription up to the line claimed by him; for, if defendant's claim is sustained by the evidence taken before the commissioner, that will terminate the investigation.— *Plank vs. Reinhart* (*Iowa*), 46 *N. W.* 1005.

20. Although it is a fundamental rule that the actual beginning corner must control in locating original surveys, yet when a survey is made upon paper, and not upon the ground, the intentions of the parties making the survey should control, which intention is to be ascertained by all the facts and circumstances connected with the case.— *Ocean Beach Ass'n vs. Yard* (*N. J.*) 20 *A.* 763.

21. There being evidence that a corner described in the field-notes with the bearing trees was found and identified on the ground, it is error to refuse a charge that calls for distances, and quantity must give way to calls for natural and artificial objects, and it is not sufficient to charge that "calls for surveys are important in the following order: (1) Calls for natural objects; (2) calls for artificial objects; (3) calls for course and distance,— but neither absolutely controls another class," where such other class more truly indicates from the evidence the true locality of the land in controversy.— *Titterington vs. Trees* (*Tex.*), 14 *S. W.* 692.

22. Plaintiff platted as an addition to a city, land of which he was owner, and signed, acknowledged, and recorded the plat as required by the laws of Oregon. Of that part of the land fronting on M. street, he dedicated enough to make the street 46 feet wide. In front of the land adjoining his, the street was 60 feet wide, and the opposite side of the street along the whole of both fronts was a straight line. He then sold lots in this addition by a map which was an exact copy of his plat, except that the dimensions of the lots were not given on the map, and that both sides of M. street, as it appeared on the map, were straight lines, thus showing the street of uniform width. *Held*, that this was not sufficient, in

the face of the plat, to show a dedication by plaintiff of enough land to make M. street of the same width in front of his property that it was in front of the adjoining property.— *Hogue vs. City of Albina* (*Or.*), 25 *P.* 386.

23. To establish the existence of a highway by dedication by deed, it must appear that the grantor was the owner of the land when the dedication was made.— *Warren vs. Brown* (*Neb.*), 47 *N. W.* 633.

24. A plat of lands, made by the owner, showing lots, blocks, and streets, but not acknowledged and recorded as required by 2 Terr. Laws Mich. 577 (1 How. St. c. 32), does not operate as a statutory dedication of the fee of the streets to the county in trust for the municipality intended to be benefited.— *Village of Grandville vs. Jenison* (*Mich.*), 47 *N. W.* 600.

25. When the acts of the owner of the land are relied on to establish a dedication of land for the purposes of a public road, an acceptance of the same by the public must be proven.— *Warren vs. Brown* (*Neb.*), 47 *N. W.* 633.

26. In order that a plat showing lots, blocks, and streets may operate as a common-law dedication of an easement in the street to the public, there must be an acceptance by the public within a reasonable time; and it acquires no rights in a platted street which it failed to use for thirty-four years, during a part of which time an abutting owner occupied the same by buildings erected thereon.— *Village of Grandville vs. Jenison* (*Mich.*), 47 *N. W.* 600.

27. Plaintiff and defendant owned adjoining mining lots. Defendant mined a quantity of ore on the side of his lot next to plaintiff. A corrected survey of the whole tract showed that the land from which this ore was taken was within the true lines of plaintiff's lot, and he brought forcible entry and detainer against defendant. The evidence showed that when the parties went into possession, the lots were marked by stakes, and that defendant's operations had been confined to his own lot as originally staked off. *Held*, that these stakes were monuments which must prevail over the courses and distances of the subsequent corrected survey. — *Jones vs. Poundstone* (*Mo.*), 14 *S. W.* 824.

28. In trespass to try title to land alleged to be part of the M. survey, it appeared that the north-east corner of the M. survey was known, and the course called for in the patent from that corner was "south, 60 west." At the north-west corner the call was for

"a stake whence a willow bears north, 63 west, 98 *varas*." Neither the stake nor bearing tree could be found, and a line drawn from the north-east corner to the stone, which plaintiff's witness testified marked, and had been for thirty years recognized as, the true north-west corner, would be "south, 61 west," and the land in controversy was that included between said lines. *Held*, that the court properly charged the jury that in locating said line they should be governed by the calls in the patent, and, if the evidence satisfied them as to the true location of said line as originally run and marked by the stakes and bearing tree mentioned in the patent, they should be governed by such line, but if the location of the stakes and bearing tree, as they existed when the patent was issued, was not satisfactorily established by the evidence, they should be governed by the courses and distances of said line as called for in the patent.— *Boydston vs. Sumpter* (*Tex.*), 14 *S. W.* 996.

29. The patents for two grants of land did not call for each other as coterminous boundaries, and neither was described with reference to the other, but each grant was described as being bounded, along the sides nearest the other, by a river, one by the left bank and the other by the right bank, and in each courses and distances were given as the meander line of the bank referred to. In an action to establish the boundary between the two grants, the court below found that the river had changed its channel considerably since the patents were issued, and that the banks, as they then existed, could not now be found or traced. *Held*, that it was error for the court below to adopt, as the boundary between the two grants, a line established by plaintiffs' surveyors by running the courses and distances along the river bank as called for by defendants' patent, and then, for the purpose of establishing the line of plaintiffs' grant, laying off a line parallel to the line of defendants' grant so surveyed, and a uniform distance of seven chains therefrom, allowing that to be the width of the river running between the two grants, where the testimony is undisputed that the river, now and of old, varied in width at different points. Beatty, C. J., and Sharpstein J., dissenting.— *Martin vs. Cooper* (*Cal.*), 25 *P.* 262.

30. Where a deed grants "a strip of land forty feet wide along the bank of the Willamette River . . . for the purpose of a road or right of way," but fails to fix the side lines of such strip,

evidence of the situation and conduct of the parties and of the nature of the ground is admissible to show that the line next to the river was intended to run along the top of the bank instead of along the water-line.— *Wills vs. Leverich* (*Or.*), 25 *P.* 398.

31. On a question whether a sheriff, in executing a writ of possession, correctly interpreted a part of the decree calling for a line from a point on a lake; "thence southward with the meanders of said lake 405 *varas* to the mouth of the lane on the south bank; thence south,"—the jury were warranted in finding that he should have run the line south from the mouth of the lane instead of from a point beyond to which the 405 *varas* carried him, since that point was necessarily variable, depending upon the distance from the water-line at which the meanders were run.— *Jackel vs. Reiman* (*Tex.*), 14 *S. W.* 1001.

32. Plaintiff in ejectment claimed a line different from that laid down in the survey, by reason of the known location of his N. E. corner. Plaintiff testified that a stake was set at this corner by the original surveyor; but this stake only stood two years. Some years after, a surveyor started with the initial point of plaintiff's survey, and running on course and distance found the witness tree of the N. E. corner, and located that corner as laid down in the original survey; and the line so run was treated as the true line by adjoining owners without objection from plaintiff. *Held*, that the evidence in support of the N. E. corner, as claimed by plaintiff, was sufficient to prevail over the courses and distances.— *King vs. Brigham* (*Or.*), 25 *P.* 150.

33. A patent by the federal government, which in terms bounds the land on the margin of a stream navigable in fact and above tide-water, carries the title only to the water's edge, and not to the center of the stream. Affirming 11 P. 873.— *Packer vs. Bird*, 11 *S. Ct.* 210.

34. Where a conveyance of a city lot describes it as beginning 298 feet from the intersection of two streets, "at or in front of the middle of a party-wall," the party-wall, being a fixed monument, must be considered as the beginning point of the description, though it is only 293 feet from the intersection of the two streets. Affirming 55 N. Y. Super. Ct. 359.— *Muhlker vs. Ruppert* (*N. Y.*), 26 *N. E.* 313.

35. Where the calls of the field-notes of the title papers under which both parties claim begin at the corner of a certain survey,

and plaintiff's title papers locate that corner at a rock set in the ground, which is there at the time of trial, but the survey made by order of court shows that this rock is not at the place where the calls in the original survey would place it, the line is not to be determined by the recent survey, nor by the course and distance of the original survey, but it is to be located by the jury where it appears from the evidence to have actually been located originally.— *Evans vs. Foster* (*Tex.*), 15 *S. W.* 170.

36. October 18, 1833, the government of Texas granted to Maximo Moreno a tract of 11 leagues of land extending northward from the San Andres River, which runs diagonally south-eastward, across its front. The original survey called for a stake in the prairie at the N. W. corner, and for two hackberries at the N. E. corner. The stake had entirely disappeared. Running the courses and distances forward, from the S. W. corner, made the east line 4,000 *varas* too long, gave no trace of the hackberries at the N. E. corner, and disclosed serious discrepancies in the other natural calls. Running them backward from the S. E. corner, gave two blazed hackberries at the N. E. corner, and corresponded much better with the other natural calls, but made the west line 4,000 *varas* too short. The north line, as called for, running forward, was blazed on the trees, and the east line was blazed northward beyond the hackberries about 4,000 *varas*, but the distances of the north line made it fall short of the east line by about 570 *varas*, and the evidence tended to show that these marks were made about thirty years after the original survey. The court charged that the jury must follow the tracks of the surveyor so far as discoverable with reasonable certainty upon the ground, and that marked trees designating a corner or line should control both courses and distances. *Held* proper, and a charge that if the marked north line, and the east line above the hackberries, were run at the original survey, they must be considered the true boundaries, would have been misleading as an independent proposition, because it ignored the evidence tending to locate the corner at the hackberries, which was the most controlling evidence in the case.— *Ayers vs. Watson*, 11 *S. Ct.* 201.

37. An old map found in the general land-office of Texas, and reputed to be the work of the original surveyor of the Moreno grant, contained a sketch of the survey, with notes indicating that the lines were run in the opposite direction from the S. E. corner.

Defendant asked a charge that if the testimony was insufficient to identify the hackberries found as the hackberries called for in the grant, and the jury could not fix the N. E. corner or the north line by any other marks or monuments, then they must fix it by the courses and distances of the first and second lines of the survey, extending the north line the 570 *varas* necessary to make it intersect the blazed east line. The court had charged the same, in substance, with the additional qualification that the jury must first be satisfied that the original survey was not commenced from the S. E. instead of the S. W. corner. *Held*, that this qualification was necessary and the charge asked was properly rejected.— *Ayers vs. Watson*, 11 *S. Ct.* 201.

38. Where the distances of a survey have been actually measured upon the ground, the courses and distances may be reversed when by so doing they more nearly harmonize with the natural calls of the patent, and the "beginning" corner does not control more than any other corner which is definitely ascertained. — *Ayers vs. Watson*, 11 *S. Ct.* 201.

39. The owners of a strip of land, on the boundary between themselves and defendants, are not estopped from asserting their title, after disputing defendants' right to enter thereon, because, misled by defendants' claim and some advice they had obtained in reference thereto, they acquiesced for less than twenty years in the possession of defendants, who did nothing in reliance on their silence. — *Hinkley vs. Crouse* (*N. Y.*), 26 *N. E.* 452.

40. Where adjoining land-owners employ a surveyor to run the boundary line between them, not because they have had a dispute about it, but merely because they are ignorant of its exact location, the line so run, if incorrectly located, is not conclusive on the parties, even though they acquiesce in it believing it to be correct. — *Pickett vs. Nelson* (*Wis.*), 47 *N. W.* 936.

41. The owner of land who has agreed to sell it, but who afterwards receives a release of the contract, is not bound by the action of the other party to the contract in agreeing with an adjoining owner as to the boundary line between them, even though he aids in making the survey. — *Pickett vs. Nelson* (*Wis.*), 47 *N. W.* 936.

42. Where the field-notes of a survey, and maps made by different county surveyors, show that the west line of a certain survey is the east line of a former survey, and that line is taken as the boundary for more than forty-seven years, the fact that the

courses and distances of the respective surveys show a gap between them is not sufficient, after such lapse of time, to prove that the surveys do not actually adjoin. — *Standlee vs. Burkitt (Tex.)*, 14 *S. W.* 1040.

43. The fact that certain monuments marking the corners of a survey cannot be found, does not render the lines of the survey unknown or uncertain so that they can be proved by parol evidence, when the field-notes of the survey afford sufficient *data* for running the lines.— *Pickett vs. Nelson (Wis.)*, 47 *N. W.* 936.

44. Where a corner, supposed to have been established by the government in the surveys of public lands, has been acquiesced in by adjoining owners of such lands for nearly ten years, and improvements made, and the land broken up to the line thus established, there is a presumption in favor of such corner being the true one, which can only be overcome by clear proof that it was not established by the government.— *Coy vs. Miller (Neb.)*, 47 *N. W.* 1046.

45. In trespass to try title, it appeared that the original field-notes of the survey of the grant involved were made in English, and subsequently transcribed and translated into Spanish, and thus carried into the grant. The surveyor of the grant, one Johnson, and his chain-bearer, both testified that the survey was made but once, and in the year 1833, and the chain-bearer said it was made in the spring. In the general land-office there were on file original English field-notes of the survey corresponding exactly with the notes in the grant, excepting that they called for four intermediate streams, while the grant called for but two, together with a map of old surveys, including a sketch of the one in question. The field-notes were dated "Sunday, 21," and April 21, 1833, fell upon Sunday. Both notes and map were reputed to be the work of Johnson, and had been on file beyond the recollection of those connected with the office. In other litigation concerning the boundaries of the grant, these documents were held admissible by the Supreme Court of Texas. 13 S. W. 768. *Held*, that they were admissible in this case.— *Ayers vs. Watson*, 11 *S. Ct.* 201.

46. In ejectment, where defendant claims that the land is within the exterior boundaries of a rancho, and consequently not included in the patent to plaintiff, and supports this claim by the original petition, the *expediente*, the *diseno*, the act of judicial possession, various maps, decrees, and proceedings, and also by oral

testimony of witnesses as to the exterior boundaries of the rancho, the evidence may warrant a finding that the land in controversy is within the exterior boundaries of the rancho.— *Foss vs. Hinkell (Cal.)*, 25 *P.* 762.

47. The fact that a patent describes the land as "the north-east quarter of the south-east quarter of section 8," instead of as lot 4, does not exclude from the grant any of the land that would properly be in lot 4, when it appears by the government plat that it was intended to pass lot 4, which was marked as containing the same number of acres as were granted by the patent.— *Sheppard vs. Wilmott (Wis.)*, 47 *N. W.* 1054.

48. The fact that lot 4 is in two quarter sections, is immaterial, as a given fractional lot may be crossed by quarter section lines, when the lines of the plat show that it was not intended to extend the intersecting line of the adjoining quarter section so as to exclude from lot 4 the land in controversy, which is necessary to make up the number of acres as called for in the plat for lot 4.— *Sheppard vs. Wilmott (Wis.)*, 47 *N. W.* 1054.

49. The tenant in a writ of entry claimed under a deed describing the land as 41.53 rods, bounded on the east and west by the lands of the grantor, but with nothing to fix either the east or west line. When the deed was delivered, the grantor pointed out four stakes, and told the tenant that the land between them was hers. By a later deed, under which the demandant claims, the grantor conveyed an adjoining lot by a description which overlaps the land between the stakes. The land claimed by the tenant includes 42½ rods, while the location of the line according to the calls in the demandant's deed would leave the tenant the full quantity called for by her deed. *Held*, that the tenant was entitled to all the land between the stakes.— *Hooten vs. Comerford (Mass.)*, 26 *N. E.* 407.

50. A conveyance describing the land by lots, blocks, or government subdivisions, and adding at the end of the description, "also, together with all other lands that may not have been heretofore described belonging to said" grantor, passes title to a lot not expressly mentioned.— *Clifton Heights Land Co. vs. Randell (Iowa)*, 47 *N. W.* 905.

51. A deed by the trustees for another part of the platted land, which describes the land conveyed by reference to the streets, and makes no reference to the beds thereof, and made in pursuance of a sale at public auction under the plat, and an advertisement con-

taining no reference to the beds of the streets, constitutes a dedication.— *Pitts vs. City of Baltimore* (*Md.*), 21 *A.* 52.

52. Under Rev. St. Ill. 1845, c. 25, div. 1, §§ 17–21, which provided for the recording of plats acknowledged by the owner of the land, the recording of a plat acknowledged by the attorney in fact of such owner does not operate as a statutory dedication of the streets.— *Earll vs. City of Chicago* (*Ill.*), 26 *N. E.* 370; *Thomsen vs. McCormick*, *Id.* 373.

53. The recording of a plat acknowledged by the attorney in fact of a land-owner does not operate as a statutory dedication of the streets; but where such owner afterwards sells land abutting on a street in such plat, his grantee takes title to the fee of the street burdened with an easement in favor of the public, since such sale amounts to a common-law dedication of the street.— *Earll vs. City of Chicago* (*Ill.*), 26 *N. E.* 370.

54. The fact that part of the land dedicated for a street does not belong to the dedicator does not avoid the dedication as to that part owned by him — *Earll vs. City of Chicago* (*Ill.*), 26 *N. E.* 370.

55. Where the owner of land makes a common-law dedication of a street, and then conveys the land on both sides of the street to one person, and the street is afterwards vacated, such person owns the fee in the land included in the street.— *Thomsen vs. McCormick* (*Ill.*), 26 *N. E.* 373.

56. Where an owner lays off his land into blocks and streets, makes a plat thereof, and sells lots indicated thereon by reference to such plat, the dedication of the streets thereupon becomes irrevocable.— *Hicklin vs. McClear* (*Or.*), 22 *P.* 1057.

57. Where parties owning contiguous estates derive title from a common author, and a controversy arises as to the boundary between them, the elder title must be first satisfied, and, when that title conveys a fixed quantity of land, the holder is entitled to take such quantity.— *Keller vs. Shelmire* (*La.*), 7 *So.* 587.

58. Where a patent of land is issued with boundaries as described in a survey and map made by a government surveyor, who has also made field notes giving not only courses and distances, but also monuments and the various topographical features of the country, the calls for monuments will control the courses and distances in relocating the boundaries of the patent.— *Tognazzini vs. Morganti* (*Cal.*), 23 *P.* 1085.

59. The city of Louisville condemned a certain strip of land for railroad and sewer purposes, and, after constructing a road-bed along this, it conveyed to the L. & N. R. Co. "its title to the road-bed, bridges, and right of way" along the entire route, and "all the land belonging to the city," between certain streets, "for depot purposes." The railroad company had formerly occupied a right of way for a double track on other streets, and the city, in consideration of the change of the railway to the street forming the line of the road in the conveyance, agreed to furnish the company a road-bed. *Held*, that along the rest of the route nothing was conveyed outside of the road-bed.— *Long vs. Louisville & N. R. Co.* (*Ky.*), 14 *S. W.* 78.

SKETCH OF ROBERT CLARK, JR.

ROBERT CLARK, JR., was born in Delaware county, New York, August 4, 1804. He was a son of Dr. Robert Clark, and was one of a family of twelve children. The family was of Scotch descent. Dr. Robert Clark was a man of marked ability, having represented the State of New York in the national Congress. A staunch adherent of the Presbyterian faith and an uncompromising Whig, he earnestly endeavored to inculcate in the minds of his children his own religious and political convictions. Young Clark had the advantage of a good education in an academy in his native county.

In 1821 Dr. Clark was appointed registrar of the United States Land Office at Monroe, Mich., to which place he immediately removed with his family, and there died about 1840. This appointment induced his two sons, John A. and Robert, Jr., to adopt the profession of civil engineers, which they followed for the remainder of their lives. When not more than eighteen years of age, Robert, Jr., commenced the practice of his profession by a survey of two islands known as the "Twin Sisters," and lying at the mouth of the River Raisin. On the ninth day of December, 1823, he received his first regular government contract from Edward Tiffin, Surveyor General of the United States, in which he agrees "that he, the said Robert Clark, Jr., in his own proper person, with the assistance of such chainmen and axmen as may be necessary (being first duly sworn), agreeably with the laws of the

United States, and such instructions as he may receive from the said Edward Tiffin, Surveyor-General, will faithfully lay out, survey, and subdivide into sections the following townships of land, to wit: Townships 4, 5 S, R 1 E; Ts. 5, 6, 7 S, R 1 W, situated south of the base line and east and west of the principal meridian, in the southern district of the Territory of Michigan." By inspection, this work proved to have been well done, and on the sixth day of May, 1825, he received a contract to survey townships 4, 5 S, of R 4, 5, 6 W, and on the 15th of December of the same year, secured an additional contract for the survey of townships 4, 5, 6 S, R 2, 3 W. Among his other contracts were the following: In 1826, Townships 4, 5 S, R 7 W; Ts. 3, 4 S, R 8, 9 W; Ts. 2, 3, 4 S, R 10 W; Ts. 3, 4 S, R 11 W. In 1828, fractional townships 8, 9, 10 S, R 4 W; fractional Ts. 8 S, R 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 W. In 1829, Ts. 1 S, R R 12, 13, 14, 15, 16, 17 W. In 1830, the exterior lines of towns 7 to 17 N, R 1 E; 12 to 17 N, R 2 E; 14 to 17 N, R 3 E; 7 to 17 N, R 1 W; 7 to 16 N, R 2 W; 7 to 14 N, R 3 W; 7 to 12 N, R 4 W; 7 to 10 N, R 5 W; 7, 8 N, R 6 W; 7 N, R 7 W.

All of the foregoing were in the then Territory of Michigan. During the years employed in this labor, Mr. Clark spent most of his time among the Indian tribes. He became familiar with their language, habits, and character, mingled in their sports and councils, or joined with them in the pleasure and excitement of the hunt and chase. At the breaking out of the Blackhawk War, in the spring of 1832, Mr. Clark offered his services in defense of the sparsely settled country of Southwestern Michigan. Gov. Porter, recognizing the value of the man, commissioned him a lieutenant of cavalry, and he was assigned to duty in the 12th Michigan Militia, in which command he served until the restoration of peace.

In the winter of 1832–33, he surveyed in what was then known as the Northwest Territory, T. 3. R. 1. 2, 3 W, 4th Principal Meridian: T 4, R 1, 2, 3 E and 1 to 6 W; Ts. 5, R 5, 6, 7 W, and Ts. 6, R 6, 7 W. This work was situated north of the north boundary of the State of Illinois, and east and west of the 4th Principal Meridian, in what is now the State of Wisconsin. This last survey was an extremely difficult and hazardous undertaking. Starting from his home in White Pigeon, Mich., on the 4th day of October, 1832, he traversed the whole distance through forests and across prairies, fording the streams swollen by the autumnal rains, and finally arrived at his work on the 27th of the same month. Provisions were high and difficult to obtain, but the abundance of game assisted

them in securing the necessary food. The country was very rough and rugged. We find this entry in his journal: "Feb. 21, 1833. Brush! brush! brush! Oh, this terrible Platte country! No wonder that no man in the mines knows anything about it. The largest tracts of it are inaccessible even to wild beasts. Nothing but a ragged surveying party could ever penetrate its horrid recesses. This day we tore through four miles." In the same journal, under date of April 6, he writes: "Last night at 2:30 A. M., an express came to camp with news that 3,000 hostile Indians were on the march, and probably by that time had sacked Galena. At daylight, after breakfast, packed up the horses to go to some fort. Found that during the night most of the inhabitants of the country had 'forted.' About 9 A. M., news came that the report was groundless. It is now ascertained that a man was chopping wood near the mouth of Rush Creek, some twenty or thirty miles from Galena, when two men came up the river and gave the Indian yell, and he ran for Galena. We became reconciled, and got to work again about 11 A. M." Twice their camp was destroyed by forest fires, with the loss of tents, provisions, etc., and the party was obliged to bivouac, and subsist as best they could, until food and shelter could be obtained. The work was finally finished on the 15th day of April, 1833, when Mr. Clark and his companions returned to White Pigeon.

During the years 1833–36, Mr. Clark was variously employed as District Surveyor of St. Joseph county, Mich., and upon government surveys in Illinois and Missouri. At that time considerable ill feeling existed between the Illinoisans and Missourians. He tells of a laughable incident illustrative of this hostility. While traveling through Missouri with his company of surveyors, he applied one evening at the cabin of a settler for shelter for himself and companions. The settler's wife eyed him suspiciously and said: "Be you 'uns Suckers or Pukes?" "Neither," said Mr. Clark, "we are Wolverines." "What kind of animal is that?" said the woman, still incredulous. Clark explained that the wolverine is not a beast of hostile proclivities, but is as gentle and mild-mannered as a lamb. This explanation restored entire confidence, and the travelers were treated to the best the cabin afforded.

Once while surveying on the eastern shore of Lake Michigan, a huge, gaunt wolf persisted in following the party hour after hour. Clark remarked that that wolf looked as though he had n't eaten

anything for a week, and would relish a dish of surveyor, rare done. One of his companions laughingly proposed to see what he had for his last meal. Raising his rifle, he shot the wolf dead in his tracks. Upon examining the stomach of the dead animal, it was found to contain only the knotted end of a tarred rope, which he had doubtless picked up on the beach of the lake.

Mr. Clark's last contract was for the survey of a number of townships north of Grand River, and not far from the present site of the city of Grand Rapids. About the 9th of March, 1837, he started from White Pigeon for this work. Mr. S. P. Williams, now living in Lima, Ind., says: "One morning, early in March, 1837, as I was passing along the streets of White Pigeon, I observed my friend Clark approaching, mounted on his favorite black horse, with his compass and Jacob staff fastened behind his saddle. Of medium size, without an ounce of superfluous flesh, a rosy, fresh countenance, hardy, cheerful, and in the prime of life, he was a perfect specimen of the early pioneer of Michigan. Extending his hand to me, he said: 'Good-by, my friend, I am off for the Saginaw country.' 'Good-by, and good luck to you,' said I. 'Thank you,' said he, 'I have need of your good wishes, for I am going to a rough, cold country, and have a hard job before me.'" Turning his horse's head to the northward, he followed the old Indian trail to Kalamazoo, stopping with his friend, T. P. Sheldon, thence north through the forest, arriving at the Grand River the next day. After procuring the necessary supplies and camp equipage, he commenced his work on the 19th of March. The next day, March 20, while returning to camp from work in the field, he was suddenly stricken with apoplexy, and died immediately. Thus at the age of 33, "while yet in love with life, and enraptured with the world, he passed to silence and pathetic dust." His body was placed on the back of his faithful steed, and transported to his home in White Pigeon, where he was buried.

Robert Clark, Jr., was a man of decided character, and of liberal religious and political opinions. Prudent in financial matters, scrupulously honest and exact in all business intrusted to him, he won the esteem of those with whom he was thrown in contact. His greatest delight was in his family, and his domestic relations were exceptionally happy.

An expert and fearless rider, he was an excellent judge of horseflesh, regarding his horse more as a companion than a slave. About 1830, he purchased a very fine black saddle horse of

P. Marantette, an Indian trader who resided near the present site of the village of Mendon, St. Joseph county, Mich. This horse carried him on several trips from White Pigeon to Cincinnati and back, and was with him on his journey to Wisconsin. It is said that on one occasion he rode him from White Pigeon to Monroe in a day and night. After Mr. Clark's death, this horse remained at the old homestead in White Pigeon, where he was kindly cared for until his death in 1857.

Mr. Clark was married on Dec. 29, 1831, to Mary E. Fitch, a daughter of Judge Charles B. Fitch, of Lockport, Mich. She still survives him, and makes her home with her son in Chicago. Mr. Clark left two children, Robert Bruce and John M. Bruce became a prominent and successful merchant in Chicago, where he died in 1864. John M. was educated with the expectation that he would follow the profession of his father. He graduated as a civil engineer from the Rennsalaer Polytechnic Institute, of Troy, N. Y., in the class of 1856; followed the profession in the States of Iowa, Colorado, and the Territory of New Mexico; was in the latter Territory during the war, and came to Chicago from there on the death of his brother, where he has since resided. He has filled several positions of trust, and is now collector of customs for the port of Chicago.

Robert Clark, Jr., at the time of his death, was possessed of what was regarded as a fair fortune in those days, consisting almost entirely of wild lands. The hard times which followed the panic of 1836 greatly depreciated the value of this property, and it was with the greatest difficulty that his widow was enabled to support herself and children, and prevent the land from being sold for taxes.

Mr. Clark's brother, John A., who learned the business of surveying with him, came west in 1840, and was employed by the government to survey the 3rd Principal Meridian, which runs through the State of Indiana its entire length from north to south. He said he did not see a white man outside of his own party on this trip, from the time he left Chicago until he returned there after the survey was completed. John A. was appointed by President Lincoln as Surveyor General in New Mexico and Arizona, and was afterward transferred in the same capacity to Utah. He was a skillful engineer and a good man.

O. H. Todd.

BUSINESS TRANSACTIONS

Of the Michigan Engineering Society for the year 1890-91.

THE annual convention was held in the pioneer room at the State Capitol, and was fully attended. Owing to ill health, the Secretary was unable to be present at the convention. A stenographer was employed to report the proceedings, but no report was furnished of the business transactions or of the addresses by Professors Greene and Denison. The reports of discussions were so imperfect as to be of no value whatever, further than to indicate in an imperfect way who took part in them. This accounts for the very meagre report that we are able to give of the meeting. The lack of a report of the discussions has been partly made good by some of the members, who have written out what they wished to say on the subjects presented. Being unable to procure Prof. Greene's address on iron tests, the discussion has been omitted. At the business meeting, the annual reports of the Secretary and Treasurer were presented. They are as follows: —

SECRETARY'S REPORT.

The Secretary would respectfully report that since the last meeting, he has transacted the following business for the society: —

Immediately after the Detroit convention, the contract for publishing the "Annuals" was let to W. C. Gage & Son, of Battle Creek. Advertisements were solicted by the Secretary as far as possible for him to do so, and the aid of Mr. G. K. Brandon was called in to assist in the work, which he did on a commission.

The work of publication was pressed forward as fast as circumstances would permit, and the "Annual" was sent out to the

members who were not in arrears for dues, the 1st of June. Exchanges were effected with the societies of Arkansas, Iowa, Indiana, Ohio, the Provincial and Dominion Land Surveyors, and the University of Michigan. These were sent to the members in the fore part of September by express. Letter ballots were sent out for members, and canvassed by the Secretary on the 1st of April, and the new members included in the published list in the "Annual." Letter ballots for officers were also sent out. In July, Prof. Carpenter sent in his resignation as President, and withdrew his name from the list of candidates for the coming year. A meeting of the Board of Directors was held at Ann Arbor, July 11. Prof. Carpenter's resignation was accepted, and a supplementary ballot for President was ordered. Ballots were sent out accordingly. The Board of Directors held their annual meeting at Lansing, October 9, and canvassed the ballots for officers, and the following were declared elected: President, J. B. Davis; Vice-President, Geo. L. Wells; Secretary and Treasurer, F. Hodgman; Directors, Geo. E. Steele, M. E. Cooley, and C. E. Greene. A preliminary program was prepared and sent to every member and every surveyor in Michigan whose address could be procured, as well as to a large number of others. The Secretary exceedingly regrets that the condition of his health is such as to prevent his attendance at this convention, but he has done all in his power to make it a successful meeting, and he sends his best wishes and kindly greetings to all the members, old and new, and wishes them a pleasant and profitable meeting.

TREASURER'S REPORT.

THE treasurer respectfully reports the following moneys received and disbursed by him during the year ending October 9, 1890:—

RECEIPTS.

Cash on hand, Oct. 9, 1889	$ 61 57
Received from members for fees, dues, and postage	221 30
" " advertisers	257 50
" " reports sold	2 50
Total	$542 87

EXPENDITURES.

Paid W. C. Gage & Son for "Annuals" and other printing	$260 68
" the secretary	50 00
" stenographer	29 12
" for illustrations not in Gage bill	29 00
" " freight and express on exchange reports	18 25
" " postage and envelopes	43 73
" expenses of Board of Directors	9 00
" commission to Brandon for "Ads"	14 00
" other expenses getting out "Annuals," etc	15 85
Amount on hand Oct. 9, 1890	73 54
Total	$542 87

These reports were accepted, and resolutions were passed expressing appreciation of the work done by the secretary, and voting him $100 for past services.

The following persons were nominated for officers for the ensuing year: —

For President, W. F. Durand.

For Vice-President, Geo. E. Steele, M. E. Cooley.

For Secretary-Treasurer, F. Hodgman.

For Directors, C. E. Greene, A. J. Teed, Geo. E. Steele, Wm. Appleton, Gardner S. Williams, and J. B. Davis.

The following names were approved by the Board of Directors for membership, and ballots have been sent out, and the applicants elected: —

Senior Members, F. S. Dewey, Alpena; P. O'Connell, Lansing; H. L. Thayer, Lansing; Philip B. Woodworth, Lansing; H. E. Terry, Saginaw; Charles H. Redman, Grand Rapids; W. H. Vande Voort, Lansing; Orlando J. Root, Lansing.

For Junior Member, Ernest Sellers, Lansing.

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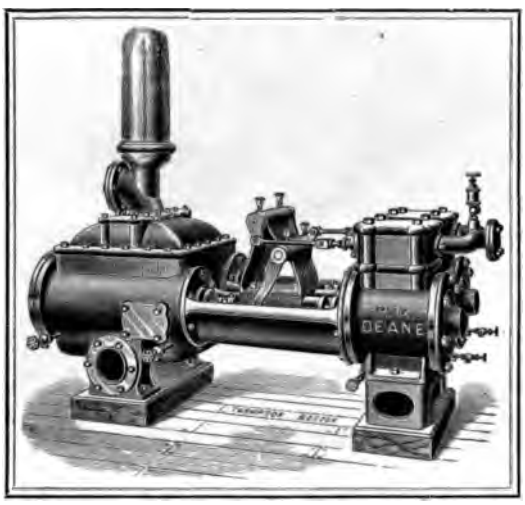

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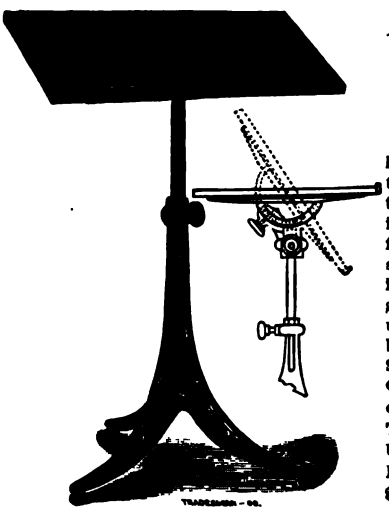

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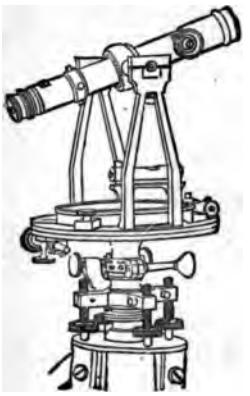

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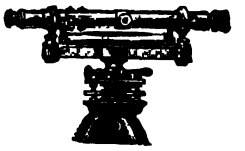

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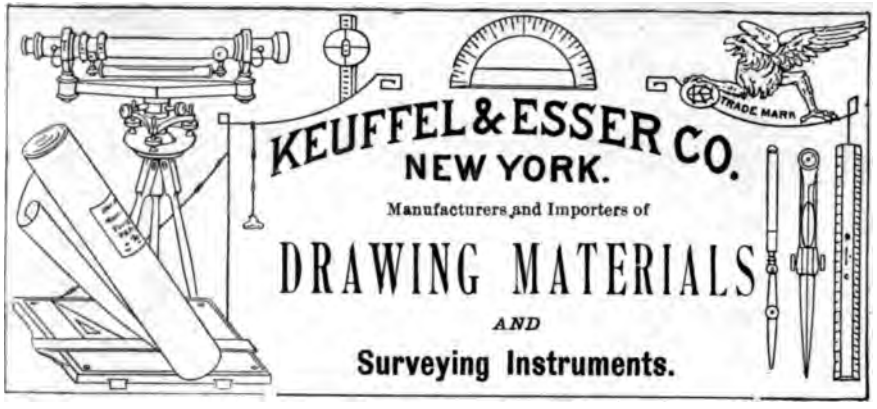

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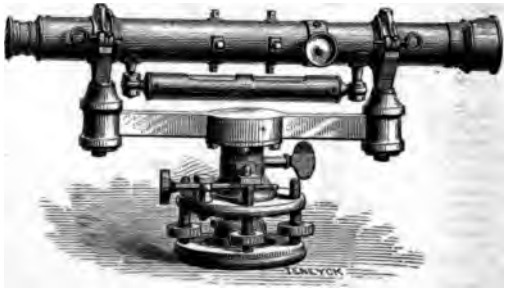

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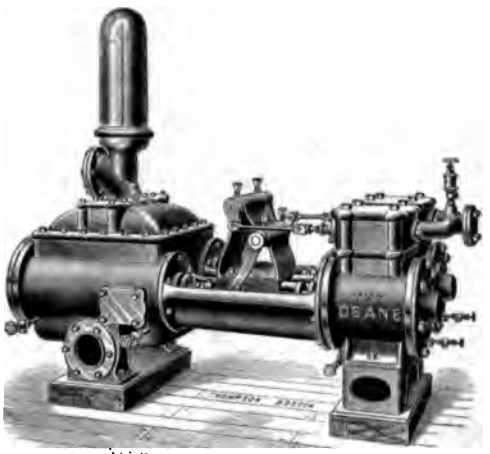

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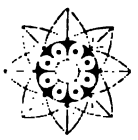

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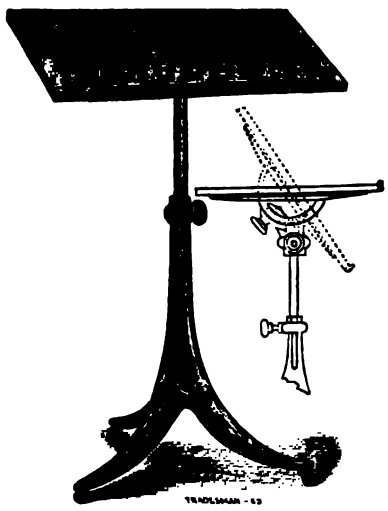

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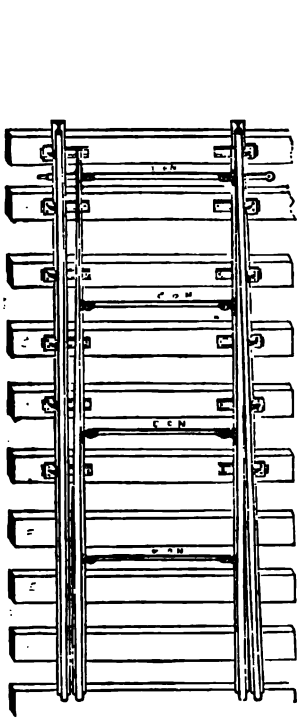

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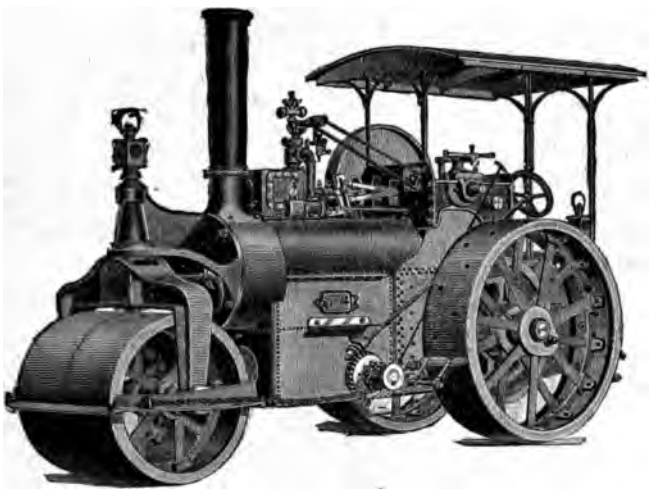

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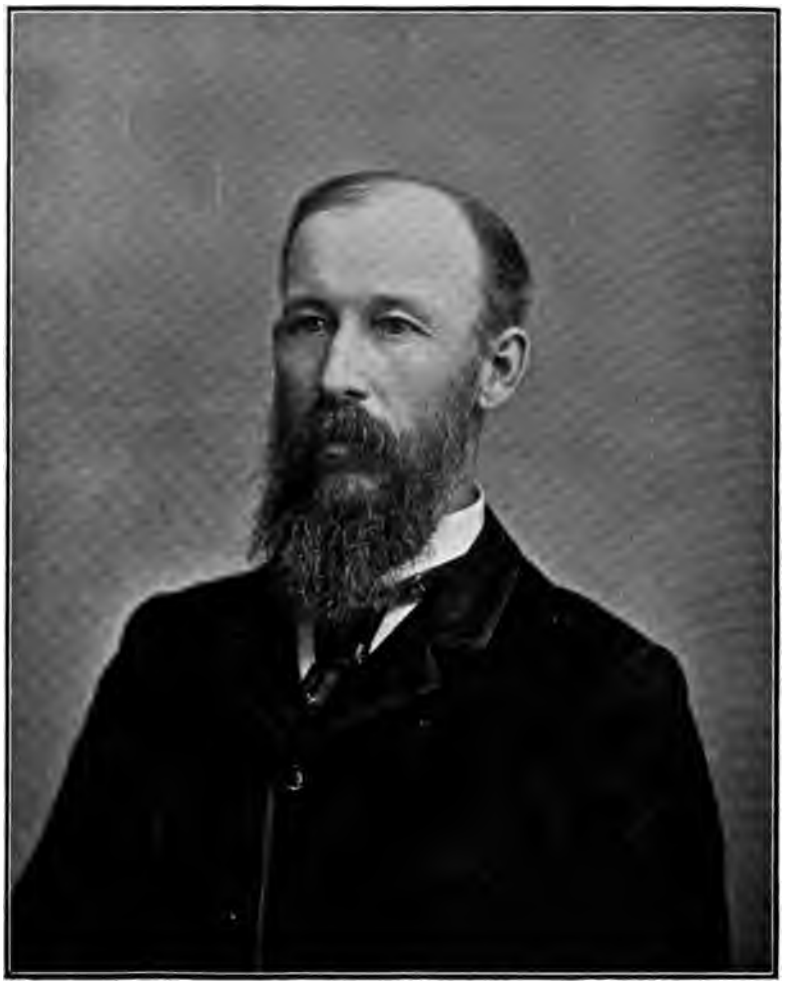

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MICHIGAN ENGINEERING SOCIETY.

ANNUAL CONVENTION, 1892.

MAYOR UHL'S ADDRESS.

The annual convention for 1892 was held in the city hall at Grand Rapids. Mayor Uhl welcomed the society to the city in a few well chosen words and continued as follows:

I ran upon some figures, gathered by the board of trade as to some of our manufacturing industries, and I see here that there is employed in capital $18,228,000, or was last year; that the value of the product was $33,555,000, as against $15,000,000 capital the year before, and $27,000,000 of product. The number of hands employed this year is 39,000 as against 13,000 the year before.

This city here, nestling in the valley of Grand river, was, but a few years ago, a hamlet surrounded by an agricultural country, but today it presents one industry that, as we think, takes the lead of all other cities in the land. It takes that lead for freshness of design and intelligence of workmanship, and while you are here gathering in your annual convention there is a great influx into this city, not only those who buy our wares, but those that come here, to the furniture center of the United States, bringing their wares to sell, and it will be as I have said, no doubt, the great privilege of the local members of your profession, before you shall go hence, to show you some of this manufactured product.

And now I bespeak for your annual gathering one of profit, one of pleasure and one of success. We tender to you, as I said in the beginning, the very best that we have, and as some one has said, the emphasis of hospitality lies in friendship, in cordiality, in attention, rather than in the externals or the accessories that surround it.

Time fails me, even were I competent, to speak of the noble profession which is yours. Would that while you are here you could show to us some way of preserving the beauty, the harmony, and the engaging grace that nature has given us in these hill-sides, and still accommodate it to the wants of man. Would that you could demonstrate to a certainty that it is the highest piece of vandalism to cut a canal through the beautiful park on the other side of the river in order that a few more loads of hay or a few more cords of wood may be brought upon West Fulton street.

Many of you are representatives of the class known as hydraulic engineers, and there is a subject which could engage the highest talent in that regard, for it has been a vexed question for many a year, a question that yet remains for solution, as to the permanent water supply of this city. That question is divided between the advocates of ground water, Grand river, Rogue river, Flat river, and I may say, Lake Michigan, and there are some who say, as far as that is concerned, except for culinary purposes, we don't need a great quantity of water in any event.

We are now taking our source of supply from the Grand river, and many of us are of opinion that if that source shall be taken three miles above where Rogue river empties into the Grand, that we shall have a satisfactory water supply.

I said a moment ago that time failed me, even were I competent, to speak of the excellencies and the glories and the beneficent results worked out by your exalted profession. We see today through its instrumentalities living results, which a decade ago we considered but the wild fictions of enthusiasts, and as unsubstantial as the stuff that dreams are made of.

Give me where to stand, said the ancient philosopher, and I will move the world. Find where to stand. Stand where you are, is the voice of science, and so your profession has done much—nay, has accomplished wonders beyond the power of tongue or pen to detail in the betterment of man, and in the building up of a civilization which today is in advance of all the ages that have gone before.

RESPONSE OF THE PRESIDENT, PROF. DAVIS.

Your honor, I suppose it falls on the president to thank you for your kind words of welcome. As I am only a sort of a president, but his representative, it falls upon me, I suppose, to say thank you, sir.

We men who live in bricks, and mud and mortar, you know are not usually talkers. That isn't a part of our business. Our business is to work. We came to Grand Rapids with the confident assurance, which needs no confirmation, of the same kind of a reception that we have met with, knowing that everything will be done for us that can be, and I spare words in that direction, to express some wishes I have.

I hope to see the day when the ships of the lakes shall make their wharves at Grand Rapids. I see no reason from what I have already learned, why that should not be done. I see no reason why you should not presently have a ten foot channel up to the city front.

It happens that acquaintances of mine and men that have formerly been in my employ, have been engaged in making a survey this summer for this purpose. I hope to see it accomplished. I have looked over the maps and plans some, and I see no reason why it may not be accomplished, and while I do not know the amount of water power you have here, I see no reason why seven or eight feet more may not be added to your present head, and perhaps that water power doubled, if you are prepared to utilize it.

As I came here the other day I saw what I suppose is your first ten story building. I see no reason why there should not be more. I see no reason why your city should not profit by every modern improvement. We who live in the State, take a pride in the city of Grand Rapids. It is, as you have truly said, the center of the furniture trade for this whole country, whole nation, and we look upon Grand Rapids as one of the features of Michigan—just as we count its other features—its wonderful, and simply matchless, system of inland navigation, yet to be improved as time passes, as we all know, and I take pleasure in referring to one particular item of that improvement which has fallen under my eye dur-

ing the past summer, which we will all take pleasure in hearing about, I think. The improvement of the St. Mary's river and the building of the new locks at the "Soo."

The opening of the St. Mary's channel will easily double the Lake Superior commerce, and that commerce now exceeds that of the Suez canal, as we all perhaps know. The St. Mary's river at the present time can be passed only in the day time. When the new channel is done, it can be passed continuously, day and night. The locks are already operated day and night by means of the electric light, so when that channel is done—'93 is the date set—in the fall –we may expect to double the capacity of that channel. It will be a 20-foot channel—indeed it is being made 21 feet. I know of no place where one can spend a few hours and receive more bona fide instruction than to sit on the canal docks of the Soo, and see the great vessels passing through there. Now a portion of that commerce must come up here. This city is entitled to it. It is only seven or eight miles to within grasp of that thing. All the fall of Grand River is in the first seven or eight miles and that can readily be overcome. While Grand Rapids extends to us, gentlemen, a most hearty welcome, I, in behalf of the Michigan Engineering society, wish to extend to the city of Grand Rapids, congratulations upon the prospect of being a sea-port in the literal and proper sense of the word. It cannot all be done at once. We know how these things are done. But I repeat, I see no reason why this city, with its wealth and possibilities, should not have a channel.

We shall take great pleasure, Mr. Mayor, in looking around your city. We come here to learn. I don't know whether I had better tell a story or not, but when I say we come here to learn, that word learn impresses me. Conceit, of all other things, is out of place it seems to me, amongst our class. I was once in the city of Philadelphia and called upon the Secretary of the National Society of Civil Engineers; he was good enough to mention my school work. He said, "I should remember your college. I have had some of your boys at work for me." I felt obliged to ask how they got along, even if I felt I was getting into a corner. He says, "There is one thing you do for your boys, you get the

conceit out of them." I said, "If you had studied to pay the school a compliment that I would appreciate, you could not have selected one that I would have thought more of." We as a profession, sir, will continue to learn as long as we are able. We come here to learn, to look around and see what you are doing, and whenever any of us have any municipal work on hand (I know I do and I understand that others do), we look to see, and ask what Grand Rapids has done in like cases, and we shall learn a great deal, and we shall use your welcome and I am sure we shall profit by it.

MAYOR UHL: Permit me to say one word in reply, and that is on the subject to which you have referred, viz.: the early improvement of the navigation of Grand river. It is a subject upon which the people of this city feel more deeply perhaps than any other. It is a railroad center, and our railroad facilities are extraordinary for a city of this size, and yet we feel, for the proper development of the city and its further growth, that this highway by water to the great lakes, should be and must be made.

And, sir, to hear you speak in terms so earnest and so thoughtful upon that subject which lies near the hearts of all the people of our city, is a matter of exceeding gratification, because we need aid in this enterprise—we need the aid of all the friends throughout the State, and perhaps in other states. As you, as president, have well remarked, this cannot be done at once, and we know that every enterprise of that kind has met with opposition, perhaps, and always obstacles, so it is a matter of great gratification to us that the people who come here and see the possible growth of this city, see its need of an outlet by way of the great lakes, and speak so earnestly and emphatically as you have done. I beg, sir, on behalf of this city, to thank you most cordially.

PROF. DAVIS: I cannot forbear one more word, if the mayor will pardon me for detaining him. But, putting the thing in a plain matter of fact way, here, we have said, is the great furniture center of the United States. Your timber line is further and further away. Your lumber has to be hauled in here by railroad to make this furniture. That timber line will recede year by year still further away, and it will be necessary

for you to seek timber in Wisconsin and on the shores of Lake Superior.

Now, shall we think of endangering a trade center of this character for the want of a ditch forty miles long, when we can dig dirt for seven cents a yard?

ADDRESS OF PRESIDENT DAVIS.

I believe it has been customary in times past for the convention to expect something from the president of these meetings, but that custom has been honored more, perhaps, in the breach than in the observance, certainly to the comfort and convenience of the members of the convention, and while I did not wish to detain Mayor Uhl to hear any remarks of mine, there are a few things that have been called to mind by his remarks, and my thoughts in connection, that I think will interest you, and if you will bear with me a few moments, I will refer to some of them.

These things I discovered while I was not a fishing. I spoke to you about the ship canal lock at the Soo and the St. Mary's river improvement. I have seen two or three things there, and heard of two or three more, of a good deal of interest to the profession. I was able to learn of a well boring device that some of you may be familiar with. This well boring device bored a four inch hole while exploring for the new lock 112 feet deep, for $3.50 per foot, in sandstone mostly, by means of a soft iron tube 24 inches long, with chilled iron shot, No. 12 to 14 under the edge of it, using a stream of water within the tube. The tube is turned on its axis, and these chilled shot are used under the edge of the tube, to make a cutting, down through the sandstone, leaving a core, which core is taken out in sections and brought out and laid on the floor. Perhaps you are all familiar with that method of boring. I was not.

It brought out a $3\frac{5}{8}$ inch core. I saw this core and so inquired with regard to some of the practical facts connected with it. Too much shot stops the cutting. Too little shot wears away the iron tube and cuts but little. It requires some skill in using the right amount of shot. The inventor, L. D.

Connor, of Petoskey, Michigan, claims he can bore large holes this way.

That was one dodge. Another one that I saw there was what is called stock ramming. Some of you may be familiar with that. I was not. There was a timber crib, filled with earth, forming a dam between the present canal and the new lock pit. This leaked, so they drove an iron tube down into it, through which they forced clay to the bottom of the dam, to fill up any openings there. The principle of the hydraulic press is used; it is extremely powerful. Easy enough to burst that coffer dam, although it is 25 or 30 feet thick. In this particular dam, the depth of the filling was about 20 feet, but I have a note here saying this process burst a coffer dam, or forced the whole depth of the filling upwards, when the depth was 100 feet.

They drive down a 3 or 4-inch pipe to the required depth. They drop this pipe full of cylinders of clay, then force the clay out at the bottom of the tube with an iron rod, and a pile driver hammer. The tube is filled and emptied in each spot until enough clay is used. I saw at the Soo where they had spread the wood work to such an extent as to sink the washers in the wale pieces outside of the coffer dam. It puts the material where wanted.

There, they were driving these tubes, and putting down the material every three feet, right across the coffer dam. Then moving to another place, and so on. It stopped the leaks.

Now there is only one other wrinkle connected with that. That is, how they make these clay cylinders, and make them cheaply. They took a common square pointed shovel, doubled it up in a circle, and welded the two corners together, so that a man thrusting it against a bank of clay, would force back on the shovel a cylindrical piece about a foot long. These were put in barrows, wheeled to the place, and dropped into the tube.

There were some other little wrinkles I noticed in connection with that lock that might be of interest, that I can mention more briefly.

The patterns for all the stones were cut out of zinc. It makes a beautiful pattern. The sand for the mortar for that entire

lock is pumped on to the scows and brought to the lock. It comes from the Lake Superior end of the work.

There is one more thing perhaps I will mention in connection with the lock; many of you are familiar with all these things, and some are not. This is a locomotive crane. It lifts 10 tons, reaches 40 feet, and its total weight, with its load, is 50 tons. It costs $4,000.00. One man operates it by five levers. One other man keeps up steam and cares for the two engines, and it works on a track 16 feet guage. This crane hoists, swings, turns and travels, and will do all at once. It will take a stone up, start off down the yard with it, swing about in the right position, and lay it on any pile.

The machinery consisted of two engines, both connected to do other service; also of a hoist, of shafts and gears for locomotion, also of shafts and gears for turning the crane. The gear frame is made of iron or steel beams. It interested me, to see it pick up a great stone as big as this table and walk off with it.

Now this new lock will cost about five millions of dollars. The dock is supposed to be 800 feet long and 100 feet wide when it is done, and even General Poe, who is in charge of all these improvements, seemed very much surprised when I happened to mention in his presence this fact with regard to the size of the lock pit. The pit is now open from end to end, and the masonry was going in last fall. The pit is about five or six hundred feet wide, and between fourteen and fifteen hundred feet long, and I happened to mention that the lock pit would contain a small sized village. The General said, "What's that?" I said, "Yes, sir, a good sized village, a street down through the middle, and good large sized lots and houses on each side." That is for handling the ships at the Soo.

The problem of the lock gates in that lock is one of the most serious that the engineers in this country have ever had to do with. The gate is to be 100 feet in two leaves. You all know how they shut together in the center. General Poe has considered the construction of these gates so important a matter that he has had engravings made of all the drawings, and copies of the plates made, to be deposited in different places, and copies of the drawings made and distributed in

widely separated localities in this country, so that they cannot by any possibility all be destroyed at once and the work have to be done all over.

And I come now to speak of the Hay lake channel, below the locks. Sorry I haven't a map, but this channel through Hay lake will bring the navigation chiefly in American waters, instead of on the boundary line of Canada and the United States. Where it now is, both sides have equal rights, and are disposed to be a little high handed in taking their rights, as near as I can discover.

This new channel will shorten the distance between the Soo and Port Detour eleven miles. They are making a twenty foot channel- -through the rock they are cutting it twenty-one. The cost of the rock excavation, including blasting, etc., by dynamite, and depositing the rock in a dyke, for the purpose of marking the channel as if it were a canal, is $1.20 per cubic yard. The rock that does not have to be blasted is 57 cents per yard, and I wish to say for the credit of the profession, that this work is being done considerably below the estimates, and the price is running below the estimates more and more as it continues. They expected the work to cost three million dollars, and the expectation now is that it will cost less than two. In fact, less than one and three-quarters is the estimate I have heard. The earth is being moved at about 14 cents per cubic yard, out of that channel; in one case, 13 cents. That will be near enough for you to form an estimate.

The channel is to be 1,300 feet wide on the bottom. That will give vessels room to pass. They have found it very desirable to manufacture the dynamite on the job. The first reason was that the percentage of nitro glycerine in the dynamite did not run even, and they couldn't depend on it, and the next difficulty was the transportation. High rates were charged. So they manufacture their own dynamite and make their own cartridges. It is the usual thing, let me say to those who are not familiar with such matters, for the drill scow, which may be represented by the table, to drill a row of holes along the front side of it, and as soon as drilled, there are 10 pounds of dynamite put into each hole and exploded right beneath one, within 20 feet. All you need to do is to raise yourself on

your toes and you will escape all harm. The rocks will be shattered below, and be picked up by the dredge. I should like to talk to you about the machinery, but I shall not do it. Visit the works and you will find it of the deepest interest. This drill scow is one of the most perfect pieces of machinery of the kind.

In case any break occurs in any scow or tug boat, it is simply towed up to the machine shop (which is afloat) and fixed. If that isn't convenient, the machine shop is towed over to where the damage is done. This gives us an idea of the magnitude of the work. These men, three, four, five, perhaps, carrying on these stupendous works, costing about $7,000,000, are doing it as a matter of course, and yet there isn't one of us, nor the whole of us put together, that is able to form the slightest conception of what $1,000,000 is.

MR. APPLETON: I do think that now you are about it, and so ably describing those operations, you might elaborate a little more on the drill scow and on the dredges. You have spoken already of some parts of it; each of those drill scows are mechanical work shops, and I think you ought to say a little more, now that you are doing it so ably.

PROF. DAVIS: If it is the desire, gentlemen, I can describe the drill scow. The beauty of it is the economy and the simplicity of it. At the side of the scow is a vertical frame. There are horizontal tracks along the outside of that frame, to which are fastened the trucks, as you may call them, which carry the drills so they can be moved along lengthwise of the scow. These drills are three in number and can all be operated at once. The drills and their shanks of course are of sufficient length to drill the holes down to 21 feet in depth—in fact a little more than that, making the drill shanks over 30 feet in length. There is a blacksmith shop on the scow, capable of keeping drills of such large size in order. On the scow, for the purpose of operating the drills, are large steam engines and boilers for handling different things about the scow, some of which I will mention presently, and for furnishing the steam for operating these rock drills. The scow is anchored at its corners, and is kept in its place and arranged so that the bottom of the channel is completely and systemati-

cally riddled with holes at the corners of five foot squares over all its surface.

I will say a word to the surveying portion of our convention. I like to talk to them. I will tell you how Mr. Ripley finds out, and he would tell you himself if he were not recovering from an attack of pneumonia, I will tell you how he finds out if the channel is the proper depth. He has a float 120 feet in length, with a hole in the middle of it, 100 feet long. Over the hole is a system of windlasses. From these chains are hung connecting to iron bars. By means of instruments, planted on the shore, he will locate that float at any place in the channel that he pleases. First, by means of his tug boat, or any other device, he will move the scow across the channel. The irons being suspended from the chains, sunk to a depth of 21 feet, will sweep the bottom of the channel completely, over 100 feet of its length. There are men standing with their hands on every chain, and the instant the bars touch bottom it is known. The scow is stopped, the sounding rod is set on that spot, the men on shore with instruments take a couple of sights to locate it, and they find that stone if it isn't a couple of inches in size. If any of you gentlemen see any way by which the contractor can escape his duty under these circumstances, Mr. Ripley would be glad to know it.

I was asked to say something about the dredges. I cannot say much to interest you. They put on dredges there that were too powerful at first and had to reduce the power to do the work economically, yet the present dredges astonish most of us. They will cut into solid sandstone rock, tear it to pieces. They bring it up in pieces up to two and three cubic yards. They found that the original dredges of the ordinary dipper pattern were too powerful. They would not work economically. They were not being worked up to their capacity, so the power was reduced somewhat and they are doing the work and making money at the present day, as Mr. Ripley confidently informs me. Where they are drilling their work they receive $1.20 per yard, and where there is no drilling to be done, for 57 cents, and this place where they took out two or three cubic yards is where there is no drilling done.

The dredges are, I think, made in Toledo; simply good,

plain, powerful machines, no nonsense, strict business. There is a great fleet of tug boats, and all that sort of thing. It is seventeen miles to the Soo, and they have their private telegraph wire running down, and everything of that kind in shape, which shows of course the size of the job, and the strength of the men who are dealing with it.

There is one other thing I saw there that some of you may not have seen, and which you have seen accounts of in the papers, probably—what is called the "whale back." The whale back is cutting quite a figure in commerce. It is a very simply constructed plate metal vessel, having very little interior framework. They are simply built for carrying and storage capacity. They are all holds and hatchways, the quarters of the men taking up comparatively little space in the ends. They are built without bulwarks. The sea can wash completely over them. They are vessels of the largest class, as large as can be admitted to the locks at the present day—in depth, not in length. They are 250 feet long, or thereabouts, are made self-propelling and also as tow barges. They can carry freight for $2\frac{6}{10}$ mills per ton per mile. One of them crossed the Atlantic, you know, during the last summer, and I was surprised to be told that it was the first vessel that had crossed the Atlantic without a mast or sail. Possibly that is true. They are a singular looking vessel, but a great commercial success; cheap in the first cost, carrying capacity very great, and the repairs must be slight. Speed is very good, good enough for freight vessels, and they will undoubtedly revolutionize the carrying of bulk freight. It is not expected that they will make any great impression upon carrying package freight, at the present day.

Now that was what I saw when I wasn't fishing.

MR. TODD: I would like to ask if these whale backs are seaworthy?

PROF. DAVIS: I didn't talk with the captains of any of them myself, but I was told by Mr. Ripley, who did, that in one of the worst storms that he experienced, he walked from end to end in slippers, without getting his feet wet. They are long enough to span the space between three waves. That was one of the architectural problems in sea going vessels. If the

vessel is long enough to span the distance between two waves, she may find herself badly strained, but if she can span the space between three waves, she will seldom be very readily misused by the passage of the waves. The shape is such that the waves can have very little hold of her sideways. Starting at the keel, coming out in the ordinary form, then straight up the sides, a short curve to meet deck, which is a flat oval, thus giving the whole cross section nearly the form of a plate girder bridge. Just a small iron tower for the people to live in. It carries from 2,000 to 2,500 tons. The way they build at the present day is governed by the amount of water in the lock. During this summer the water has been very low, and they have only allowed vessels $14\frac{3}{4}$ feet.

Another thing some of you may know and some not, the passage through those locks is free to all vessels. It belongs to the United States government, and no tolls are charged whatever.

MR. HODGMAN: Speaking to the question as to whether the boats are sea worthy, one of those vessels went across the Atlantic ocean to England, and went around the Horn to Puget sound, and got through all right, except the loss of a rudder plate.

MR. MUMFORD: Around the Horn or through the straits?

MR. HODGMAN: I mean in a general way that she went around the southern continent, but I presume very likely she went through the straits.

MR. MUMFORD: In the connection where Prof. Davis says the length was about 250 feet. A vessel would encounter seas of a much greater length at times. I had an experience myself, right off Cape Horn, in which the captain and I estimated the length of the sea by the length of our vessel, about 156 feet, and we thought the vessel covered one-third of the slant height of one side, which would make 150 feet even.

I was present at a meeting where Captain ———— was present, and he suggested when the argument was made, that the cradle would strain a ship beyond endurance. He had made a test on one of the White Star liners, and found that the straining of that vessel, when she was running before the sea amounted to six inches, with perhaps 300 feet of deck.

PRESIDENT: Oh, yes; more than that perhaps on that sized vessel. Any of you could make the experiment on an ocean steamer, when on board. I think you are right in your statements, but that sized sea is seldom found on the lakes. These vessels are found, I think, very safe lake boats.

I have not attempted to speak of their advantages as ordinary vessels, because I have only wished to draw your attention to what to me is an interesting part of engineering, the naval part, and to suggest to you, something going on within our own borders. Their advantages for bulk freight are in loading and unloading. They are practically open from end to end, when the hatchways are removed. The hatchways are steel or iron plates like the rest of the vessel and secured in place with bolts and packing until they are water tight. The vessel is just as smooth as painted iron. It looks like what its name implies, like a great big whale. They call them pig noses, I believe.

MR. APPLETON: I saw 63 large vessels go through those locks in 24 hours. A person must be there to realize the amount of traffic.

PRESIDENT: I would say in addition to Mr. Appleton's remark, they are not scows, and flat boats, and fishing boats, and tug boats, but the finest class of steel and iron vessels, of the largest size, that money will build. Vessels, the outsides of which are as fine as money will make them, say nothing of the inside.

Well, gentlemen, I must ask your pardon for prolonging these rather desultory remarks so long. I do not wish to interfere with other matters that properly come before the convention.

THE BUILDING STONES OF MICHIGAN.

PROF. W. H. PETTEE.

Some of you may recollect that at a meeting held at Lansing a paper was announced by me on this subject, Building Stones of Michigan. The manuscript I had there was after-

wards printed, giving some little account of the properties of building stones, the things to be looked for and the things to be avoided, and I intimated then that possibly there would be more to be said on that subject at some future meeting. At the time the program for this meeting was made out by the standing committee, it was thought the time had come for me to put on that appendix, whatever value it might have. I want to say, however, that I have no great amount of new information to add to what was said at that time, and have not prepared a written paper. I shall have to rely upon the stenographer for a report of what I say.

The study of the building stones of Michigan, or the study of the properties of the building stones of Michigan, has not been carried on to any great extent, so far as I am aware, by the geological survey, or by any other persons connected with the public works of the State. At the Mining School Mr. Sharpless is engaged at present in the examination of the properties of some of the building stones of the State. I have a letter giving some information of the progress he is making, but not very minute or ready for publication.

During the past year some things have come to light in regard to the opening up of new quarries. Specimens have been sent to Ann Arbor by private parties, but the amount of new development seems to be very small indeed; so, I think, that, if I direct your attention to two or three points connected with what may perhaps be expected here in the State, and what some of the points are that it is desirable for an engineer to look out for, my object will be accomplished.

In the first place, then, we can draw a sharp line of definition between the stones that are found in the Upper Peninsula and those in the lower. There is undoubtedly a large amount of sandstone exposed in good, accessible quarries along the southern shore of Lake Superior. Most of you are familiar with the character of this red sandstone, and know that these quarries (of Lake Superior) have been advertised very largely, and that the stone has been used in the building for the Mining School at Houghton. It is too early to say much about the durability of the stone. I cannot help getting the impression, in looking at it in buildings, however, that the stone is rather porous, and that it will absorb good deal of water.

If a piece of sandstone, when put into water, will take up five or six per cent of its weight by soaking 24 hours, its porosity is about that which you can expect to find in a good durable sandstone. That is accepted as a good limit. I had some specimens brought down from the Upper Peninsula this winter, and they were examined at the laboratory; their absorption ran a little higher, say eight or nine per cent, not enough to reach the danger line, but still a little beyond the line of safety, if we know what that line is. This is not the best of building stone from this point of view, and still not so bad as to be rejected. Looking at the building at Houghton, I could not help feeling that it looks a great deal better now than it will five years from now. I fear that the frost will make its way in and that the sharp corners will be rounded off.

In a report of some analyses of those building stones at Portage lake, I am informed there is a large, an unexpectedly large, amount of feldspar. I do not know whether that will prove to be true or not. Sandstone is made up of grains of quartz sand cemented by some cementing material, and we do not usually find feldspars in these sandstones. Ordinarily the feldspar of the original rock from which the stone is derived has become worn down, carried off in finer form, deposited in clays somewhere else, and we do not often get the feldspar in these sandstones; but Mr. Sharpless writes me that in these sandstones he finds, in all cases, feldspar, and that is an ingredient which might not be regarded as very favorable. It is regarded favorably in stones of a different character, but not sandstone, as it might lead to earlier decay. But whether there is feldspar there or not, I have to say I am in doubt, because within the last week or two specimens of the sandstone have been examined in our laboratory, and we fail to find evidence of the presence of feldspar grains. The chemical analysis shows a great deal of alkali, potash and soda, and these are supposed to indicate the presence of feldspar. Another explanation is that the clay which is present as the cementing material, is of an alkaline character. Some clays do contain quite a little amount of alkali, and it is an open question whether the alkali in the sandstone is due to the presence of feldspar or the presence of an alkaline clay. Questions

of that kind need to be considered with care, and experiments tried, before we can determine positively whether these ingredients are favorable or unfavorable to the durability of these stones. The general impression which I get from such examinations as I have been able to make of the Upper Peninsula sandstones, is that while they are easy to quarry and very pretty, they are quite uneven. Stones from two quarries, looking very much alike, may prove to be very unequal in value. There is no trouble about the strength. The stone is strong enough. There is no danger of crushing, but the trouble, if any, is going to be in lack of durability. Now, if you do not care anything about the looks of the structure, that will not be serious, but for use in cities, or places where architectural effects are to be studied, I am afraid that these stones will wear out a little too rapidly. I do not want to have it go on record that I say that will be the result. It is the impression I get from what study and observation I have been able to make of these stones from the Upper Peninsula.

They seem to be pretty free, however, from anything in the way of sulphur, pretty free from iron pyrites. That is in their favor. Iron pyrites, the common mineral you see so frequently in coal and rocks, yellow, brassy looking cubes, is generally looked upon as one of the most undesirable elements in building stones; and, if that is absent, that is much in their favor. So far as I have been able to ascertain, the presence of iron pyrites is rather rare in Michigan sandstones.

In regard to pyrites and its bad effect upon building stones, I may say here, not specially in connection with the building stones of Michigan, but building stones in general, that we all know iron pyrites has a very bad name; and it deserves it in many cases, but sometimes not. There is iron pyrites and iron pyrites. The chemical combination in iron pyrites is that of iron and sulphur. We know of several different combinations of iron and sulphur, which do not differ much in general appearance. The ordinary observer would call everything of that brassy kind, probably, pyrites, and let it go at that. But when these are studied with more care, using a microscope, we find that there are certain varieties of pyrites that are easily decomposed, very susceptible to the action of water and the

atmosphere. But there are other varieties which are not affected in that way at all. You will see a stone put in a wall of a building, perhaps, looking perfectly free, clean and pure, and in the course of a year or two it will be covered with iron rust, while in another stone containing visible pyrites the crystals will stay as bright as ever.

You may not know why it is, that some iron pyrites decomposes readily and some does not. It has been made a subject of study recently and the result may be stated in this way: There are small differences of specific gravity in these varieties of iron pyrites. They run up to 5 and sometimes a little more, $\frac{1}{10}$ perhaps, and they also occur as low as $4\frac{8}{10}$, or, in some cases, $4\frac{6}{10}$. Now these differences seem to be pretty small, but they are connected with differences of internal structure, and we find that those slight variations in specific gravity point to differences of density in the molecule, differences in compactness of the atoms in the pyrites; and if the specific gravity of your iron pyrites is $4\frac{95}{100}$, you will be pretty sure that the weather will not affect it; but if the specific gravity is $4\frac{9}{10}$ you can be pretty sure that in the course of a few seasons it is going to rust and discolor the rock.

To return to these sandstones of the Upper Peninsula, we have every reason to believe that they will be very valuable for a great many purposes, although I fear they will not be so desirable for work that is to retain architectural beauty for any great length of time. I hope I am mistaken. Some of the members present can, perhaps, give additional information, and may know of buildings that have stood for a good many years and retained their beauty; and certainly no one will be more glad than I, if the impression I have gained is corrected by those better informed. The sandstones in the Upper Peninsula seem to be about the only variety of stone there available for building purposes in general. They are of a high geological age, going back to the paleozoic formations. There are, to be sure, a good many limestones, found at the southeast end of the Upper Peninsula, near Mackinaw. I have not heard of their being used to any great extent. A sample from a quarry in that vicinity was brought to me last year, the owner thinking it might be valuable as a marble. The stone had

taken a pretty good polish, but when looked at carefully and with the microscope, it appeared that the surface was not exactly smooth. It was pock-marked, and showed little indentations about the size of the head of a pin, some larger and some smaller; and, on being broken, the stone revealed the fact that wherever one attempted to get a polished surface, even three or four square inches, three or four little openings would be cut across, which would open channels for the penetration of moisture, and soon cause the polished surface to disappear. It does not seem to be a desirable stone for a marble that is to take a good polish. It would be too coarse grained and have too many openings.

In the Lower Peninsula we meet with a difficulty that we all understand; the country is covered very largely with gravel, and we have to go down from 50 to 200 feet before we get a good rock.

I have not gathered any special information that is new in regard to the few quarries that are opened in the southern peninsula. You know of them, some at Grindstone City, at Ionia, and several others, but I have no additional information in regard to them beyond what was included in my paper three or four years ago. The geological age of the rocks in the Lower Peninsula is, generally speaking, more recent than that of those in the Upper Peninsula, though still paleozoic.

I see no reason why we should not find good building rock in the limestones, though we do not get good granite rock. There is a good supply of granitic and crystalline rocks in the Upper Peninsula, but I do not think a quarry has been opened that would supply a rock to compete with the granitic rocks of the East, and Appalachian region.

Now, Mr. President, in this way as you see, without manuscript and quite off-hand, I have presented a few points I thought might be of interest, and with this I will call the paper closed for the present, subject to such discussion, to criticism, and retraction as the case requires.

PRESIDENT: I am sure we are all glad to hear from Prof. Pettee on this subject, and in this practical kind of a way, and I think many of the members, though whether they are here or not I am unable to say, will be able to add something to

what he has already given us with regard to their experience with these different stones from different localities.

I would like to ask if it is possible to tell from the surface exposures of the Lake Superior sandstones anything about how they will act. There are great cliffs exposed in different localities. Also, I would say on the general subject, the use of building materials, in which stone forms a large part, that the climate of Michigan is so extremely trying on the exterior of all buildings, that I think materials for any permanent buildings should be selected with the greatest care and in the light of all the information that can be obtained from experience, or which can be got from anywhere.

PROF. PETTEE: In regard to that matter of natural exposure. I do not think you can tell very well from the outcrops of the exposed cliffs around the shores of Lake Superior as to how the stone will work when put in a building. One reason is that the conditions are very different. The conditions to which the rock is exposed, are far different in the quarry than when in the building.

It is pretty generally believed, and recommended in our books of reference, that the best thing an inquirer can do is to go and see where the rock has been exposed, and if it has stood exposure there pretty well, it can be believed it will stand exposure in the building. The principal criticism against that belief is that when you come to put the stone in the wall of a building, exposed to the atmosphere of a city, it will very likely deteriorate much more rapidly than it would in its native fields, and instances are given, and might be referred to by the works at hand here, where rocks from a given quarry that have been used in public buildings in a country community, have stood for centuries apparently without injury, while rocks from the same quarry, taken into the cities, have crumbled away and become disintegrated within a comparatively short time. The atmosphere of our cities contains a rather large amount of sulphuric acid and other gases, which seem to have an injurious effect on the stones exposed to view. That is a subject in regard to which I am unable to give you any quantitative statements at the present moment, but there is no doubt about the fact.

In answer to your question, Mr. President, I would advise you not to depend with much certainty on the character of the exposed cliffs. It is not a safe guide. It gives you some information, but nothing you can tie to.

MR. SKEELS: I would say for the information of some of our friends that the Michigan Trust Company have used that Portage stone for two stories of their building, and it can be seen by going on the ground.

MR. AMES: The Hermitage on the corner of Canal and Bridge streets is trimmed with the red sandstone, Lake Superior stone, and the Michigan Trust Company building is the one mentioned last evening, one block from here.

PRESIDENT: Mr. Forster, who is not present, is more familiar, perhaps, than the rest of us with the localities mentioned; he could tell us something of the history of these things if he were here. Sorry he is not.

PROF. PETTEE: If I might be allowed to add just one word, this subject of the importance of building stones in Michigan is one which I understand the geological survey is beginning to take up and study with a little more care than has been done heretofore. With reference to that matter of feldspar, Mr. Sharpless wrote me that in all of his reading and research he had never found any reference to it whatever, and he is preparing a monograph on the subject of the strength and chemical composition, and physical properties of such stones as are used for building purposes around the peninsula. I am looking forward to his report with considerable interest.

The secretary calls attention to the fact that I omitted all reference to a kind of building stone that personally I am quite familiar with, the hard-heads and boulders that the southern peninsula is full of. The stone was brought down from the Upper Peninsula in the glacial period and distributed around here. I had in mind, however, the stones that are quarried. Down in our neighborhood, Ann Arbor, the farmers have cleaned the fields pretty free of these hard-heads, but it makes very excellent building stone. It is not a building stone that will become an article of export.

MR. HODGMAN: They have in our section a very important use as foundations for buildings. They are used almost

exclusively for that purpose. Every building has them for a foundation wall. I have noticed in some cases whole buildings built of them, and it seemed to me that they were about as ornamental a stone as we had. The professor says they were brought down from the Upper Peninsula. The question is, if they were brought down from there, are there not some left there in places—the original quarries from which the glaciers took them.

PROF. PETTEE: The professor of architecture at the Columbia College School of Mines, was particularly struck with the beauty of the Ann Arbor buildings made from these hard-heads, or boulders, several fraternity houses and churches, and he wanted to know where in the world we got that stone that gave such a beautiful purple tint. I told him we had collected it from all parts of the northern peninsula, and the ice had brought it down. No two blocks of stone in these buildings are exactly the same. The boulders are found on the ground in masses as large as a horse can draw, and when they are broken open each one is different. I do not think that any one kind would be so desirable. It is the mixture that makes the beauty. If we went up to the quarries in the Upper Peninsula we should have to do a good deal of traveling, but when we have them brought down by natural forces the expense of transportation is reduced to nothing.

MR. HODGMAN: Where I reside, we have had difficulty in getting rid of them in some places.

MR. SKEELS: I would like to ask the professor if he knows anything of the stone they are quarrying at Holland. There is a great deal being used here for foundations. It is soft when quarried, and gets harder as it is exposed to the air, and makes a very nice looking foundation.

PROF. PETTEE: I have never seen that stone at all.

MR. SKEELS: And while up I would say that one of our enterprising citizens, or two of them, the Fox brothers, have built a house, corner of Cherry and College avenue, of these hard-head blocks. It is a very splendid structure. As the professor says, there are no two of them that look alike.

PRESIDENT DAVIS: While we are speaking about the field stone, I would like to ask Prof. Pettee if I am right in suppos-

ing that the field-stone of eastern Massachusetts, whose exterior appearance resembles our field stone somewhat, cannot be worked at all as we work our field stone, with hammers and fire, I am under that impression.

PROF. PETTEE: I do not know any reason why they should not. I was born in eastern Massachusetts; my father had a farm there, a few miles out from Boston. I was the youngest son. The work was all done before I was born, but, as he was troubled with a large number of field-stone boulders, he built with them what was known throughout the neighborhood as "the stone barn," 100x40, and he used many large stones in the foundation, which was about eight feet thick. That is a standing example of field-stone in a building in the neighborhood of Boston.

PRESIDENT DAVIS: What I refer to is the flat surface. We take our 30-pound hammers for pounding, and sometimes we use fire to get a crack started. My father, who has had plenty of experience, when I told him of the manner in which we worked our field stones in this country, laughed at the idea that anything of the kind could be done with Massachusetts field stone.

PROF. PETTEE: I know we used to blast them, in Massachusetts. Those of my friends who have visited me at Ann Arbor have expressed considerable surprise at our method of treating these stones.

PRESIDENT DAVIS: I was questioning whether my father's limited experience, was really a representative fact or not, that the eastern stone could not be worked as we work our Michigan field stone. I thought there was a suggestion in it for us.

PROF. GREENE: Michigan stones are granite I believe. I know when I was in Maine they would break them up with a hammer.

HYDROGRAPHIC SURVEYING.

JOHN HARRIS FORSTER.

Surveying on land is, of course, a familiar operation to most of you. All are not as familiar with hydrography.

The surveys of sea coasts, of the great lakes and rivers of this continent, have been conducted by the government, thereby debarring private enterprise and affording no opportunity for practice to the majority of civil engineers and surveyors. The writer having had some experience in this work, has been encouraged by your worthy secretary to submit some practical points for your consideration. He will not undertake to unfold the whole scheme of hydrographic surveying so ably carried out in the survey of the northwestern lakes, for instance, by the government of the United States through its war department. In brief, he will attempt only a few disjointed sketches, hoping thereby to give you, who may be interested in the subject, some idea of the work.

The survey of the northern lakes was not limited to mere off-shore soundings, but embraced shore-line surveys and topography, and a limited reconnaissance of the interior; also, deep-sea soundings, primary and main triangulation, reaching across rivers, bays, and the wide lake itself. All rivers of commercial importance, present or future, emptying into the lakes, were accurately surveyed as far up from their mouth as the case required. Especial attention was given to the mouths of rivers where sand bars and clay banks occur, choking the free outflow of the stream. The soundings at such points were minute and comprehensive, covering the whole delta. The finished chart would show a complete picture of the bottom, with its shoals, bars and tortuous natural channels. The material composing the bottom, ascertained by the lead or by borings. whether of sand, clay, gravel, boulders, hard pan or solid rock, was carefully noted. A plan was thus given which would be of great service to those who should follow in the work of river and harbor improvements.

The survey of the great lakes extended through many years, four or five decades, and was completed only a few years ago. It had for its superintendents, from time to time, army engineers who, later on, became distinguished generals in the war on the union. Captain Meade was one of the most brilliant and accomplished of these superintendents. Serving under him were many civil engineers. He called them his "boys." The "boys" loved and respected their commandant. Returning from the victorious field of Gettysburg, after receiving an ovation in Detroit, he sought out his "boys" and spent a delightful evening with them, recounting not the deeds of ensanguined Gettysburg, but the old camp stories of the lake survey.

The survey was well organized and well equipped. It consisted of several shore parties or camps. An iron steamer was attached. Its duty was to place the shore parties in the field in the spring, visit them once a month with the mails and provisions, and for inspection. The steamer also made the deep-sea soundings, and conveyed the officers conducting the main triangulations to their several stations, miles apart.

Belonging to the survey were several independent field parties. They were widely posted along the chain of lakes.

There were about twenty-five men in each party; four officers, one foreman, one cook; the rest were boatmen, chainmen and axmen. They lived in tents. There were usually two or three cutter-built, six-oared boats and one bateau, which last was used in transporting provisions and camp equipage belonging to the party. In camping the places preferably chosen were sheltered bays or mouths of streams, but sometimes the open roadstead had to suffice for the anchored boats. During heavy storms, in such case, the flotilla was hauled out on the beach. The tents were usually pitched on high, dry land, under the pine trees, near the shore, with a water view and a broad sand beach for a promenade. Thus situated, the camp, with its white tents placed in order, with underbrush cleared off, presented to the view a cozy hamlet in the wilderness. For many years the camps were isolated. There were no settlements, no human habitations, except the Indian wigwam, to be seen. During the entire season, it may be, the party saw no

one in civilized garb, except the men on the survey steamer. Long stretches of the lake country was an unbroken wilderness. Dropped some still afternoon by the steamer on a wild, untracked shore, the surveying party was left to its own resources. Before the retiring steamer was out of sight the camp was pitched, the stars and stripes flung to the breeze, the cook busy over his stove and the camp fires blazed cheerily. Our surveyors were "at home" to all callers, including the impudent mosquitoes.

Camp comfortably established, on the morrow at 5 a. m., real work began. The men were classified and assigned to the command of the several officers. Thus there were two or three sub-parties in camp. The senior officer commanded the whole. Surveying instruments were brought out and adjusted, and sounding lines compared. One gang of men was set to work making buoys, another was sent to clear out lines along shore, erect sounding stations, instrument stations, as well as secondary triangulation stations. All were busy as bees. On the first clear night an observation was taken to determine the true meridian and variation of the magnetic needle. Every ten miles, as the work progressed, new observations were made for the same purpose. The shore line was run with a theodolite. The start at the initial point was from the established meridian. The needle was never used, except to get the variation.

HOW TO MAKE BUOYS.

The buoy is an important factor in hydrography. On the survey a good practical buoy was gradually evolved. Dry cedar trees were procured from the swamps. This wood is light, buoyant and not easily water-soaked. A tree about one foot in diameter was best. It was cut into pieces, two and one-half to three feet long. One end was shaved off like a truncated cone and a two-inch auger hole bored into it. Into this hole a spruce pole about two feet long, two inches thick, with a wedged end, was driven firmly. A hole was bored through the lower end of this stick large enough to let the anchor rope pass through and tie. The top of the buoy, sawed off square, was also bored and a light spruce staff, five or six

feet long, inserted and securely fastened. On this staff a small flag, one foot square, was tacked.

A large number of buoys and flags were required. The flags were made of cotton; white, red and black were the colors preferred. Practice determined that these colors were best for use, under all circumstances. This was important; it is often difficult and perplexing to make out a buoy on the water.

These primary colors, so to speak, admitted of many combinations. For example: No. 1 might be solid white; No. 2, red; No. 3, black; No. 4, white and black (horizontal bars); No. 5, red and white; No. 6, red and black, and so on. When these combinations were exhausted the colors were placed vertically, with the same number of variations as before. If more flags were required, diagonal bands were used. These flags were all made in camp, from bolts of cotton cloth.

Each book of soundings and each book of shore-line work, had these buoy flags recorded and painted in them and duly numbered, in order that the observer, on land or water, might have a ready reference. With naked eye, or telescope, the observer could pick up one of the many fluttering flags in the offing, when, by referring to his book, he would find its name. In sounding, before the boat leaves the shore, the officer in charge must ascertain definitely which flag or buoy he is to steer for. There must be no doubt about the buoy; any confusion of flags would cause a loss of a line and a breaking up of the plan for the day.

The buoy ropes used were of manilla, one inch in diameter. The anchors, carefully selected stones found on the beaches and weighing from 10 to 50 pounds. A coil of rope was carried in the boat.

In placing the buoys we ran out from the shore, sounding the while, until we found one fathom of water. Upon the six-foot curve, technically so-called, the first buoy was dropped. The line was extended up and down the coast several miles, but within a convenient row to camp. These buoys in line were several minutes apart or from 500 to 1,000 feet, according to circumstances. The character of the bottom determined how near or far apart buoys should be placed. The engineer was called upon to exercise his best judgment in the matter.

With a smooth, even, gradually descending bottom, the buoys could be placed systematically; but with a bottom irregular, with abrupt depths and shoals and twistings, no fixed plan could be followed. The first line of buoys dropped, the boat's prow was turned seaward and proceeded until the two-fathom curve was found. Then another line of buoys was strung out. In the same manner the three-fathom curve was found and marked with buoys. Care was taken all the while to place the buoys at equal distances apart on all the curves, or lines, so that, when the work was done, the field in view was covered with many bright, fluttering flags, which marked a number of squares on the water. The shore parties were required to sound out only to the three-fathom or eighteen-foot curve, with small boats. The steamer engaged in deep sea soundings ran in to the three-fathom curve and thus connected the whole work.

This was the devised plan when all was plain sailing—when the coast was regular and the bottom descended gradually from the shore, shelving into deep water.

At times the conditions were altered. A submerged or submarine point would be encountered. One six-foot curve, usually a few hundred feet from shore, would take a turn suddenly out into the lake and we would have to row a mile to find six feet one inch. The twelve-foot curve would be equally preposterous, while the eighteen-foot curve would be three or four miles from land. This irregularity was followed out until, from some extreme point marked by a buoy, the curves farther on began to retreat toward the shore and resume their normal place. The sounding had developed merely an unexpected shoal point, putting far out into the lake. Of course the buoys on this point did not stand in the regular order before deliniated. Their location was more perplexing, from boat or from shore.

The first section or division of buoys being placed, the work of sounding began. A six-oared boat was used. The leadsman stood on a platform in the bow. The coxswain and an officer sat in the stern. A lead line was used. The coxswain's duty was to keep the boat in a straight line for either buoy or shore station. The officer, with watch, pencil and

note book in hand, gave the order to "heave." The boat was rowed at about four miles the hour, but winds, waves and currents were likely to vary the even motion. In shallow water the lead was cast every quarter minute; in deeper, every half minute; in deeper still, every minute. The officer must be argus-eyed, quick and nimble. He marks time, gives the order to "heave" the lead, notes in his book the sounding called off by the leadsman, sees that the men are pulling steadily, and that the coxswain is not napping or zigzagging, or that the wind or currents are not driving the boat off a true line. The leadsman must be quick to cast his lead and call off, giving the depth of water to an inch, character of bottom, whether of sand, gravel, clay, boulders or hard pan. All these things must be quickly noted by the engineer, and while the line is being run there is no pause or cessation of close work and attention.

In sounding from shore stations to buoys, from buoy to buoy, the whole surface, nearly, is gone over. The squares are sounded, while diagonal and double diagonal lines cross the squares. Thus the bottom of the lake is pretty thoroughly explored. No considerable shoal or even boulder escapes the searching lead. On a hot summer's day sounding in a small boat is rather monotonous. The direct and reflected rays of the sun are scorching; foggy or windy weather is perplexing, but a calm day, when the signal flags hang limp to the mast, why, you simply have to row to the shore and take a siesta under the greenwood trees.

The water survey is connected with the shore line by means of the sounding stations. At a distance to correspond with the distance between the buoys in front, these sounding stations are erected. Theoretically this is correct, but a crooked shore sometimes prevents exact practice. A sounding station is one of the shore line points. It is marked by a stake and by a tall pole bearing Roman numerals. Barrel staves, whitewashed, were found to be excellent materials out of which to form the numerals. The numbers could be seen with the naked eye a long way from shore. The whitewashed figures, on a background of fir trees, were conspicuous objects.

LOCATION OF BUOYS.

These buoys are instrumentally located by the engineer running the shore line. This engineer usually had his hands full. At every station at which his instrument was set, he was obliged. to sight at. or take a shot at, every buoy in sight. Twenty or fifty buoys could be seen and their position, by angles, be noted in his field book. Thus, by repeated observations, from different stations on shore, he was able to make many intersections, and these intersections, when he came to plat his work, defined the position of each buoy. Buoys if let alone would stand a whole season; but when a particular section on the water was completed, the buoys were taken up, carried forward down the coast, and placed out again. If for any reason a buoy could not be located from the shore a sextant observation at the buoy settled it.

In deep-sea soundings the lead was cast once in five minutes. Where the line was cut off by approach to the shore, in three-fathoms water, a sextant observation fixed the point. These lines were carried across all deep bays and across the lake itself.

PLOTTING SOUNDINGS.

In plotting soundings it is found that vastly more figures are taken than a sheet of paper will hold. Therefore characteristic soundings are chosen, care being taken to select always those figures indicating the shoalest water. There is no danger in deep water; shoals are what navigators fear. In deep sea sounding the steamer often runs against a snag, so to speak. The leadsman monotonously sings out "ten fathoms," and again, after the lapse of five minutes, "ten fathoms," then five minutes later, with a quick, sharp cry, "two fathoms!" Then all is commotion. The drowsy officers are instantly on their feet and the bell "stop her" is rung. The anchor is dropped and the boats lowered. A rocky shoal is discovered in the midst of the waters. A survey of the shoal is made; it is found to be several acres in extent; at one point there is scarce ten feet of water. A water station is erected on the shoal as a warning to mariners. This station is connected by main triangulation

with the main land, and its geographical position fixed. Subsequently a lighthouse is built on this isolated, submerged island.

WATER STATIONS

are large or small in accordance with the depth of water in which they are to be placed. The station is in form a tripod. Sticks of cedar or spruce, from fifteen to thirty feet in length, eighteen inches diameter at base, tapering to the top are best. The three sticks are bolted together flexibly at top. They are spread so as to make a firm base. They have to resist the action of the wind and waves. Eight or ten feet from the top, strong cross-pieces are spiked on, as spreaders. The lower ends of the sticks of the tripod are sharpened, sometimes shod, with iron, in order that they may sink into and find a firm footing on the shoal. The station is built on shore and towed out to the shoal, loaded on a bateau or raft of boats. Then it is dumped overboard on its feet. A platform is built on the girders aforementioned, and loaded with stone to hold the station in place. A tall flag pole with a flag surmounts the structure. Plenty of whitewash is applied. The station thus becomes a cheap and conspicuous day beacon, and will stand until the ice carries it off the succeeding winter.

SHORE LINE SURVEYING.

Starting at the initial point on the determined meridian, the surveyor begins work. His skilled foreman has already cut out his lines and selected his points of observation. To do this requires good judgment on the part of the foreman. On a winding, wooded shore his aim is to get the longest lines practicable, without running into the water on the one hand and into the bush on the other. After the surveyor has made his instrumental observation, always reading both verniers and recording the degrees, minutes and seconds, one of his trustiest men takes his theodolite, carries it forward to the next station, sets it over the stake and levels it. Meantime, our surveyor starts his chainmen, following and watching them closely and, at the same time, sketching in the topography minutely. He

is kept very busy. Arrived at the second station, he takes his shore line instrumental notes; then he sights at all buoys in range, at every secondary and primary station to be seen, backward or forward or across the bay. Thus he multiplies checks upon his work. It is hard, laborious, absorbing work. Accuracy is indispensable. From five o'clock in the morning until sundown there is no let up, except for a hasty luncheon at noon. The dinner pail always accompanies the party. At the end of a hard day's work the party is often five miles from camp. A rapid walk thither finishes the day—and the engineer also. A frugal supper of tea, hardtack and pork awaits him, and he is invited to sleep on a downy couch of cedar boughs, covered with a buffalo robe and blankets.

There is an astronomer and computer attached to these surveys who have well known special duties to perform.

Base lines are measured by the same men who do the general surveying.

I have now given you a hasty and very imperfect sketch of hydrographic work on the lake survey.

Detroit city was for many years the headquarters of the survey. Late in the fall all camps were broken up and the parties returned joyfully to the city. The men were discharged, while the officers settled down to office work. Computations and plotting the survey on a large scale was the work of winter. This was done by the men from the field. Office draughtsmen took these large charts, reduced them and prepared a combined general chart for the use of navigators, after publication.

The writer will now give some examples in hydrography not recorded in the annals of the famous lake survey.

Having been transferred to the river and harbor improvement department, he was ordered to proceed to Lake George, St. Mary's river, Michigan, to lay out the work for the proposed dredging therein, and in Neebish rapids.

His commanding officer, an accomplished engineer, afterward a general of division in the union army, and who was shot to death at Chancellorsville, had just returned from the western deserts where trees and water were particularly scarce. He took upon himself the task of providing, while in Detroit, buoy anchors and staffs, to be transported by steamer several

hundred miles to Lake George. He had a lot of cast-iron mushroom anchors, weighing about seventy-five pounds, made. He sent up to the hickory forests of St. Clair river for green poles, twenty feet long and four inches in diameter at large end. These were the materials for his buoys. The idea was brilliant. The writer quietly asked: "What shall we do if we find more than twenty feet of water, or very shallow water? These poles are not flexible; they will not stand up if the wind blows and waves roll." No answer was vouchsafed. Military discipline must be maintained. At length we reached Lake George and pitched camp on a small island. We had to clear away the timber. The shores of Lake George were clothed with a dense growth of cedar and maple trees. The first observation made by our gallant commander was: "Why, there seems to be nothing but woods in this country; we need not have brought those poles all the way from Detroit." There was a superfluity of boulders on our island, just right for buoy anchors.

We began without unnecessary delay to lay out the channel to be dredged. We used the mushroom anchor buoys. We set them with care, and the double line of hickory poles standing proudly above the waters was really like business.

There was a little puff of wind that night and some sea on. When we resumed work next morning we rowed out to the channel, but not a flag pole was to be seen. It was suggested that the Indians had stolen the buoys for the sake of the iron mushrooms. But we cautiously pulled over the ground and, as the water was very clear, we could see the bottom plainly, and our lost buoys lying there prone on the ripple-marked sand! They were suffered to remain there.

The writer was then ordered to make some buoys to suit himself. With plenty of the best material at hand the men soon produced an ample supply, a la lake survey.

In reconnoissances of narrow and crooked channels the writer found that the ordinary cedar buoy, as described, was too cumbrous for rapid work. So he invented what he named a duck buoy. This was simply a piece of dry cedar, one foot long and three inches thick, with an auger hole in the middle. A piece of marline was tied in this hole with a light stone

anchor at the opposite end. A pile of these buoys were placed at his feet in the boat. As the boat proceeded and the depth of water called off, at a certain depth, say seven feet, he would immediately throw a buoy overboard, which floated like a duck. The next sounding would perhaps be twelve or fourteen feet, showing we were in the channel, and the next heave would be in seven feet, or on the channel bank, and then over would go another duck. Thus a line several thousand feet in length would be marked out on the left bank. Returning by the right bank a parallel line would be formed, thus showing roughly the course and width of the hidden channel. Those ducks were admirable guides; by them we could deliberately set out the permanent buoys and make exact soundings.

Lake George, a widening of St. Mary's river, is in shape much like an egg, about twelve miles long and four miles wide in the widest part.

The earlier fur-trading vessels and all commercial vessels of necessarily light draft, down to 1858, followed the natural channel, which swept around near the east, or Canadian shore, in British waters.

The lake survey early in the fifties made a minute survey and chart of Lake George. The chart, in addition to the old British channel, showed a winding, partial channel, close to the west, or American shore. By much dredging this channel could be rendered navigable. From patriotic notions, doubtless, this inferior channel was recommended by the engineers as best for improvement, being entirely in American waters. Accordingly this channel was staked out by the writer and the dredges set to work. They excavated from the first 2,000 cubic yards per day, in the soft clay.

Occupying the middle of Lake George there was an immense plat of refractory red clay. It was this dam, so to speak, that crowded the waters into the deeper troughs which wound around near the main land.

The water was beautifully clear, the overflow of that great natural spring, Lake Superior. One day the writer climbed an old triangulation station, left by lake survey parties, for observation. The whole beautiful lake lay under his feet. To his surprise he saw, extending half way up into the clay flats,

from the lower end, a narrow, deep blue streak of water, like a finger. Surely, he said, there must be deep water there. He hurried down, rowed to camp and examined a chart of the lake. The chart indeed showed at the point under examination numerous soundings of twenty-five to thirty feet, apparently in line, running in a northerly direction, but the proper distinguishing curves had not been drawn. Perhaps the men were careless in sounding and, if the sudden jump from seven feet, the depth of water on the clay flats, to thirty feet, aroused their attention, they probably concluded that the thirty-foot soundings indicated nothing more than pot holes. Yet, the channel was as distinct as anything could be. The writer, in his small boat, found it so as he rowed from one end to another.

This important discovery was reported to the war department. A commission of engineers was sent from Washington to examine and report on it. They came, saw the channel as defined by numerous gay flag buoys, stayed one hour and returned whence they came. The position and importance of this new channel was apparent at a glance. Its adoption for improvement, instead of the west channel where the dredges were at work, was unanimously favored, because it was more direct, was in American waters, and would cost many thousand dollars less.

Two weeks later, orders came to move the dredges over to the new ground. Anticipating the final adoption of this line, the writer had buoyed it out, so that within one hour after he received his orders to make the change, the dredges were swinging their cranes in the new channel line. It was at midnight when this was effected. Several thousand dollars were thrown away by dredging in the wrong place. The completed channel is the one now used by the vast commercial fleets that visit Lake Superior.

At the Neebish rapids, below Lake George, the writer had a conundrum to solve.

At the Neebish, the mighty river St. Mary is crowded into a narrow bed with high ridges of quartzite rock on the east side.

Right in the middle of this narrow passage, in some past geological age, there was dropped an immense mass of boulders

which now form a dangerous shoal reaching almost up to the surface of the water. On either side is a narrow channel eighty feet wide and from fourteen to twenty feet deep. The navigation is exceedingly dangerous. The common, most used channel, is the one on the Canada side. The lake survey party found the west, or American channel, and pronounced it preferable to the one on the east side, being straighter and shorter, and carrying at least fourteen feet of water all the way through. The course through it was marked by the engineers by forward and back sights. On this course lanes fifty feet wide were cut back into the woods, cleared of all timber. High, whitewashed stations were set up in these lanes, forming conspicuous guides. As the vessel approached the rapids, these stations were brought in range and, on that range, the vessel was assured of sufficient water to carry her through safely. Large steamers were confidently invited to try the new channel. One, the Planet, accepted the invitation and, keeping close on the ranges, managed to stave a hole in her bottom the first time trying. Of course, navigators condemned the new passage vigorously. It was asserted "that them lake survey chaps were humbugs." That was the opinion of old salts. The surveying steamer, with chief of survey, immediately visited the spot and spent two days in sounding and sweeping the bottom with drag ropes, all in vain. No rock or obstruction could be found. Consequently there was a counter blast on the part of the survey, and the captain of the injured vessel was accused of running out of his course. Nevertheless, the new channel was tabooed by navigators, one and all. Desuetude was the fate of that modern discovery, the new channel. The logic of fate was against it.

The officer in command of the harbor and river improvements believed in that rock and was determined to find it. Many plans were made on paper, some quite expensive, to achieve that object. But, planning in the city of Detroit was not effective. The writer was finally ordered to find that rock somehow. The ways and means were left to his own invention when he should arrive on the Neebish. In due time, the writer, in command of a Mackinaw boat, rowed by four half breeds, whose dialect was a compound of Chippewa and French,

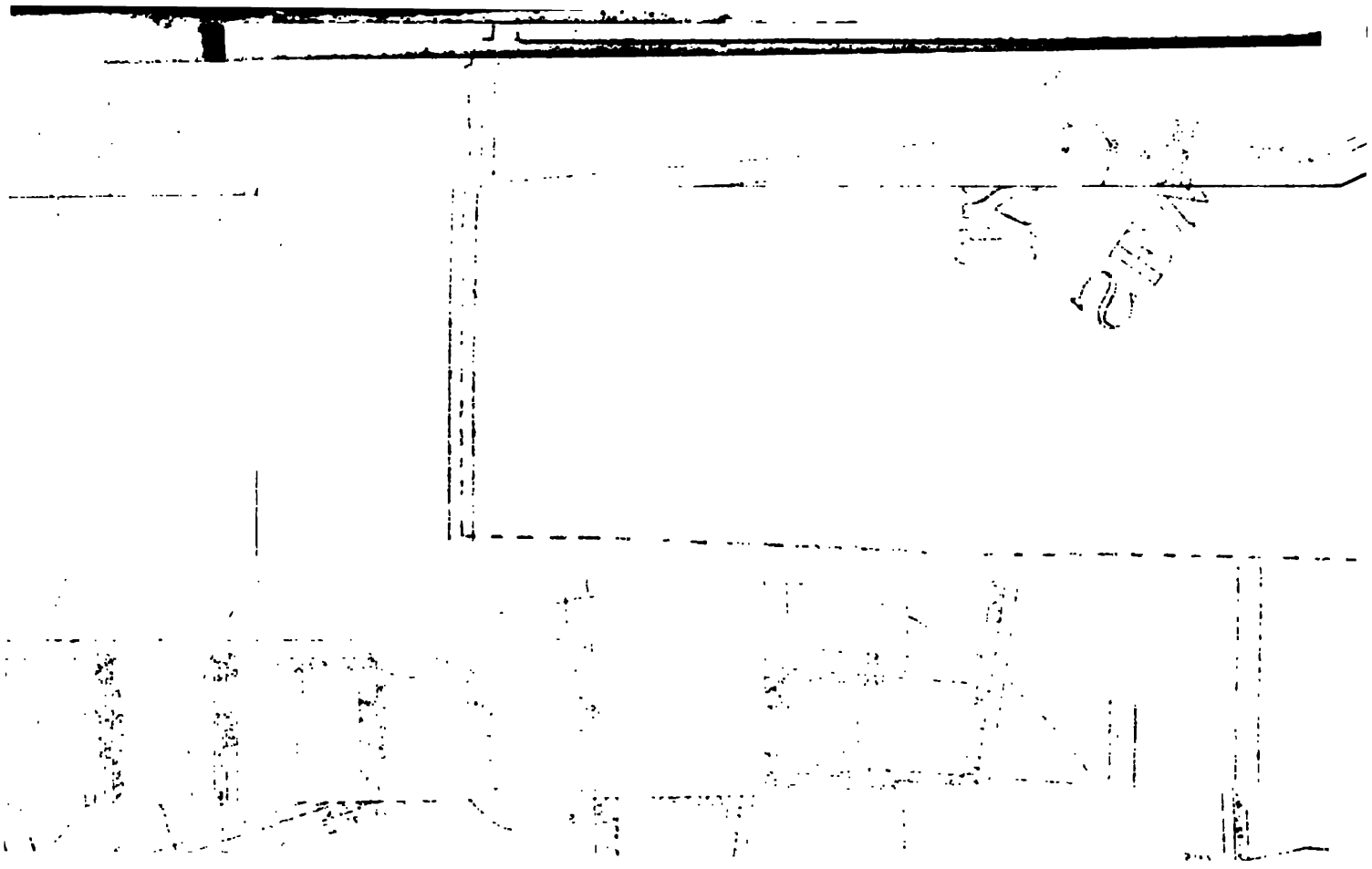
with ropes, buoys, sounding lines and provisions in abundance, pitched two tents on the American side of the rapids. He then sat him down on a boulder to study the conundrum. The difficulties of the situation were apparent. The chief one was the current; it swirled past at the rate of six miles per hour. It was impossible to row the boat against the stream; impossible to row straight across. How then should the sounding be done? As night closed down upon the dark, rushing river, no answer came. The writer, with no appetite for supper, brooded over the camp fire for a while, listening to the gutteral converse of his men, who could give him no advice, at length sought his tent. Lying on the ground, in the stillness of this solitude, only the murmuring of the rapids could be heard, but with awful distinctness. No sleep visited his eyes, but far on in the night a plan of procedure developed itself in his weary brain. At daylight the camp was awake and alert. A cup of coffee and piece of hard bread sufficed for breakfast. Then we prepared to execute our plan. We had a long coil of buoy rope, 800 feet in length. This we proceeded to measure and mark off every ten feet with strips of red flagging. We cut a light spruce sapling, twenty feet long, peeled it, and marked it off in feet and tenths, thus making a sounding pole. We loaded the Mackinaw with these, some large buoys and a small anchor. We towed the boat up the rapids into still water, and embarked. Rowing some little distance up stream, we threw over two buoys, in range with the range stations on shore. We dropped anchor at the lower buoy with our long rope fastened to the anchor. The men were directed to drop down stream backward, keeping the boat exactly on the range buoys and paying out the rope slowly. The writer, amidships, used the sounding pole, sounding at every tag of ten feet. Indeed, he kept the pole on the bottom as near as he could all the time. Slowly we dropped down. The pole measured fourteen feet depth, again fourteen feet—fourteen feet—fourteen feet—seven feet—hold on to her! Overboard went a duck buoy. Then we felt around for the rock. There it was, sure enough! We threw over a large buoy with a heavy anchor, to mark the rock permanently. Singular enough, the rock was found to be exactly on the range line. The closer a vessel clung to the range, the

more certain she was to hit the rock. There was plenty of water on either side of the rock. The writer, within a day or two after finding the rock, piloted two vessels laden with iron ore through the channel, keeping just west of the buoy.

Within one hour after work began, that diabolical rock was spotted. We returned to camp joyfully and spent the rest of the day fishing. Splendid, gamy bass in those rapids!

Late in the summer we dredged that rock up. It took all day to do it. From its peculiar shape it eluded the dipper. At length the dipper seized it. The weight made the chains snap, the crane creak and groan, bringing the bow of the dredge under water. At last it was swung onto the dump scow. It was a huge sandstone boulder, weighing several tons. It was badly marred and scratched; there were old scratches on it, showing its previous contact with steamers' bottoms. It was shaped like a flatiron, firmly bedded in hardpan, with the sharp, pointed end standing up. It was the ugliest natural vessel destroyer ever seen.

You may ask why did not the lake survey engineers find this rock? I answer, that following the usual plan in sounding rivers, by straight and diagonal lines, from bank to bank, with a lead line, it was not surprising they missed it. In that swift current it would be impossible to run straight lines. The boat would invariably sag, or, in other words, curved lines would be sounded. Of course, when these lines were plotted on paper as right lines they would be faulty. Moreover, the usual way of sounding may do for bays, lakes and quiet streams, but where the current is swift and the bottom rocky, some better way must be found to insure accuracy.



THE SEWERAGE OF MEDINA, NEW YORK.

O. C. GILLETT.

The village of Medina, New York, is the location of the celebrated sandstone quarries. The corporation is about two miles square and contains five thousand people. It is divided into four parts by the Erie canal, extending east and west, and by the Oak Orchard creek, which runs from south to north. The surface slopes to the north and towards the creek. The creek, north of the canal, runs in a deep gorge. The rock lies quite near the surface, and renders it necessary to exercise great care in designing sewers so as to have them deep enough to answer the purpose, and not to entail unnecessary expense by going too deep in rock cutting. There were in the village two or three stone drains, with rubble walls, laid dry, and covered with flagging. These, in course of time, were made to do duty as sewers, instead of being restricted to their legitimate use as drains, and with the usual results. A large part of the village had no drainage at all, except onto the surface of the ground.

For a long time efforts have been made to get sewers built for the relief of some particular locality, but without success. In 1889 the legislature passed an act authorizing incorporated villages to appoint boards of sewer commissioners. There are five of these commissioners and they serve for five years without pay. They are not to be all of the same political party; one goes out each year. By a little management the board of trustees of the village of Medina was induced to appoint sewer commissioners under the act of 1889. The sewer commission is authorized to expend not to exceed one thousand dollars for sewer plans for the village. These plans must be submitted to the state board of health for their approval before they become effective. The state board of health sends an expert sanitary engineer to look the ground over with the plans in hand. Their action is based on his report.

If the taxpayers so decide the whole system may be put in at once and the village bonded. Otherwise, on a proper petition of the property owners on any street, the sewer commission has power to lay a sewer in that street, if they deem it proper. By an amendment of the sewer act the streets which have a continuous line of sewers are to be taken for sewer purposes as one street. This enables people at the upper end of a line of sewers to get an outlet when those at the lower end are all opposed to it.

Under this law the sewer commission of Medina employed the writer to make plans for the sewerage of Medina. These plans were duly approved by the state board of health, and in April, 1891, the first sewer was constructed on West street. It is about a half mile long. Other petitions have since been presented, and two and one-third miles additional of sewers are now under contract.

I will now describe the method of preparing the plans:

Center street runs through the village from east to west, entirely across the corporation. West street runs from the corporation line on the south to the canal on the north. By running a transit line through these two streets they could be platted, and nearly all the other streets platted from them by measurement, without the taking of angles. The levels were run through the centers of the streets and alleys, care being taken to note accurately the street intersections. The party consists of a leveler, two tapemen using a steel tape, and a rodman. The hind tapeman notes the street intersections. Buildings with low foundations or extra deep cellars are made note of. Angles in streets between intersections are measured.

After the map is made, the contour lines are drawn, the location of the main outlet is decided upon, and the study of the location and grades, and sizes of the sewers begins, the nearness of the rock being kept constantly in mind. After the depths were determined, the grades were fixed, care being taken to keep the top of small sewers discharging into larger ones level with the top of the larger ones, or a little higher where possible. The sizes of the sewers which do not take surface water were then calculated by Weisbach's formula, and the storm water sewers by the formula proposed by J. W.

Adams. Although Weisbach's formula is much used in sewer calculations, it does not strictly apply. The formula supposes that the water enters one end of a pipe and discharges at the other, while in a sewer the liquid enters the whole length of it. There is also the matter of minimum grades. Writers on sewer construction give lists of grades to secure a given velocity, on the supposition that the pipe runs half full, while the truth is that the upper ends of small sewers have only a very small stream drizzling through them, with much less than the theoretical velocity due to the given grade.

The writer's greatest tribulations have been in the rebuilding of old drains. They are annoying from the sewage found in them, and the constant discharges from house drains, and also from the demands of lot owners who have usually small dry stone drains connecting their cellars with the old sewer. They insist that these stone drains be connected with the new sewer. They get in the trenches, in the way of the workmen, and stand and measure and argue as to the proper pieces of pipe they need to make the connection. If their house drain is choked with earth, and you miss it and do not leave a Y branch exactly opposite to it, then the flood gates of wrath are opened wide. My experience teaches me to avoid the rebuilding of old drains.

The following is a list of the lengths, sizes, depths and percentage of rock in the sewers now in process of construction:

Length.	Size.	Depth.	Per cent rock.
788	24 inches.	7 feet.	0.0
462	18 "	6 "	0.0
1,094	15 "	7 "	5.0
485	12 "	8 "	5.0
1,354	10 "	8 "	15.0
6,615	8 "	7½ "	
728	6 "	6½ "	8.0

The 8-inch pipe is not all in at this writing, so I cannot give the amount of rock. It will probably be about 30 per cent. The contract was let for a lump sum of $11,500.00, or about one dollar a foot. There are three Y branches to each

100 feet of sewer. There are eighteen lampholes and sixteen manholes. The manholes are built of stone taken from the trenches and covered with a cast iron cover. The lampholes are made with vertical pipe, covered with a cast iron cover. The present prospects are that the contractors will make a reasonable profit. The annexed map is a plan of the sewer system of this village.

I have written this paper to call attention to the provisions of the New York sewer act, and also to the method of making sewer maps by co-ordinates, using two long streets at right angles, or nearly so, as co-ordinate axes.

PLATS FOR THE SURVEYOR'S OFFICE.

E. STRONG.

The object of this paper is to suggest to the Engineering Society of this State and other states the entire advisability of improving and adding to the records of the county surveyor's office, by supplying it with certified copies of all plats of additions.

The time was when the county surveyor was supposed to need only a sheet of foolscap paper with skeleton notes carefully copied thereon. Sometimes they were carefully paid for, and carelessly copied. I well remember in an early day using just such a sheet, copied in perpendicular columns, and one number or letter of a post being left out, the following section corner trees came at the quarter posts, and the quarter trees came at the section corners; and these notes were used for a long time with the error undiscovered.

But that day has gone by, and the county surveyor's office is supplied with correct notes throughout the State. Another day, however, has come to us and is not likely to come to an end without help and, for one, I think the time has come when the matter should be discussed seriously. That there is great need of reform is plainly apparent when we come to examine the practical working of the present system, or lack of system. No surveyor will venture to survey a lot in an addition from

the deed alone. It would be unsafe to do so in a plat of his own making, after a year had gone by. Now, if he happens to live at the county seat, and all the platted lots in the county are located there at the county seat, he can use the records in the register's office nearly as well as if they were at his own house. But as a rule the county surveyor does not live at the county seat. In our own county such a thing has not happened more than once in twenty-five years, and so far as can be judged without statistics, in taking the average of all the counties of the State, the office has not been located at the county seat one-fourth the time. Of course all towns and villages, and stations platted cannot become county seats.

This wide separation and divorce of work and surveyor and record, leads to waste of time, unnecessary expense and inferior work. When first called upon for a difficult survey, at home or away, we all know how valuable is a half hour of quiet study, with all the notes and records before us. Plans are made for the work, just where to begin, how to proceed and end, and what the outcome will be and how long it will take. "Alas, for the plans of mice and men!" Once upon the ground, facts are found to be stubborn, and circumstances will alter cases very much; and you can just as well predict what will be done in a coming game of checkers or chess as in a game of surveying—how it will come out, and who will get beat, and how long it will take. Nevertheless, all this previous study and planning should be carefully made in every instance, and the plans adhered to as far as practical. When it becomes necessary to change materially the method of survey, how important it becomes to take another good look at the plat itself. Indeed, it is sometimes impossible to do anything but guess work unless you can get something from the plat which you have not written down. The county seat is ten miles in one direction, and you live ten miles another way, with no right to send for the plat or carry it with you. Well, you will do the best you can; there is no doubt about that, notwithstanding popular legends and old stories to the contrary. Yes, the surveyor will do the best he can, and sometimes is sorry he cannot do better. It rains, and the work is finished, and perhaps a month will

pass before he will be called again to the register's office, and a glance at that plat tells him where he missed it.

At a distance from home and also away from the town where the work is, the time given to the study of a plat, in a public office, is usually too brief, too much interrupted. You begin to realize that, for once, you have too many friends to say good morning; your time to examine and copy is limited; you are fearful that you will omit something which you will need on the ground, and your fears are likely to come true and introduce you to others. The end of all this is trouble for yourself and patrons. They are vexed and you are ashamed, and yet realize that you have not had a fair show, which is true.

This is not a fancy picture; it is not imagination; I wish it was. But all this can be changed, and changed for the better. Let us turn over a leaf and look on the other side, and look at a different picture, if possible; and why not possible? We should be able to make a better showing in this passably mature age of the world. There will be improvement along this line some day, sooner or later; why not now? This is certainly a fair question to ask, and the answer should be as fair.

With a copy of all the county plats in his own office, the surveyor has all these records just where he wants them, and just where they should be, where they will do him the most good, do just what they were calculated to do, and make of the surveyor a more self-reliant man, because he has something to fall back upon continually at hand, which, in cases of rare need, he can carry with him and consult as often as he likes. I have seen a great many surveys made with the plat in the field. It is an excellent way, not alone for the surveyor, but the parties interested are better pleased. It is an infallible source of counsel which the surveyor will appreciate because he has so long done without it; indeed, too long without it. Then the people can expect such service as they pay for. They will be the chief gainers by the change. Every poor man who buys a lot and gets it surveyed will be better served to have the county surveyor supplied with all the notes in his own office, which it is necessary for him to make use of in staking his lot. He should be so supplied. He is not.

The mere fact that the office is liable to change hands at any time by the success of political parties or friends in a caucus, is an additional reason why the office itself should be as thoroughly equipped as possible, so that the work shall be as well done as a new man can do it, who has at hand every facility. It will always be impossible for each and every county surveyor to privately supply himself with a copy of all the plats in the county. It must be done for the public office of the county surveyor, and at the expense of the county, as to the plats which have already been made, and at the expense of the owners in the future plats. These plats should be compared and certified to, by register and surveyor, as provided in other cases. The size and material of which these copies should be made it would be well not to limit within too narrow bounds.

This scheme which I have briefly outlined is a work that will be highly useful, not for a few days only, but for all time and for all coming occupants of the surveyor's office. Whenever a lot owner consults the surveyor for advice, the latter will be able to answer all questions relating to the plat at once, just as he will answer any for you now from the U. S. notes and maps. This is a matter of public information, for which there is constant application, and in which the surveyor feels himself lost, for once, because he is not now supplied with expensive records which he should certainly possess.

The county surveyor is the only county official who is presumed to be able to interpret recorded plats and give advice upon them, which will be taken as authority. By constant reference to them he will not only learn what they contain but the errors which have crept into their make-up, and which must be provided for or eliminated before making any surveys. We all know the vagueness and indefiniteness of some of the oldest and most important plats in the State, and how can the surveyor be reasonably expected to handle these like a master of his trade unless he has an opportunity to devote leisure moments to their study? He is expected to, and will be able to stand up to that expectation if he is given a reasonable chance.

So far as I know, there is but one obstacle in the way—the expense. But this is a secondary question. It is more important that the work should be done than that it should be done

cheaply, and there is this to be said, that so far as future plats are concerned, there need be no public expense any more than there is now in placing a plat on record. The law on plats might specify that a copy also be filed in the office of the county surveyor. And sure enough, why not?

EXPANSION OF AN AMPLITUDE.

H. C. PEARSONS.

Mr. President and Members of this Association:

Wishing to contribute my mite to our annual feast, I offer such as I can. My work being foreign to that of most engineers and surveyors, I have but a narrow choice of topics with which to entertain you. I offer the "Expansion of an Amplitude" for your consideration.

The finding of meridian, or azimuth, may, perhaps, be considered a subject somewhat trite in this fraternity, but a new method of utilizing an amplitude, by extending its availability from a few minutes to a few hours, may, perhaps, be worth a few minutes of your time.

We all know the value of an amplitude in finding direction, and we all know, too, how fleeting and short-lived is this valuable element to the surveyor. We have only time to get a glance at it, when it is gone—vanished.

But I have recently discovered a property in the rate of the change in sun's azimuth, that gives a great value to an amplitude, and that is a property of uniformity in the rate of the change of his azimuth, when the latitude and declination are of the same name, between sunrise, or sunset, and the time of his crossing the prime vertical.

Though this change is a function of both the latitude of the observer and the declination of the sun, the effect of declination on this change of azimuth, between the limits above mentioned, and above latitude, say 38°, is so small as to be inappreciable by any of our ordinary surveying instruments, *i. e.*, for all practical purposes of the surveyor, it may be called sub-

stantially uniform, though the rate of change increases slightly with the increase of latitude.

I use a table of time azimuths in orienting ship for compass errors, and I discovered on a number of times, when interpolating for the rate of change of azimuth, in early morning, or late afternoon, that this rate of change, between sunrise and prime vertical, and prime vertical and sunset, was uniform for all declinations in the same latitude. This led me to investigate the question, which I have done, with the results as above stated.

The following table gives the rate of the sun's change of azimuth, within the limits above specified, for a few parallels of latitude, to the nearest quarter minute, for one degree of change of azimuth:

Latitude.....	36°	38°	40°	42°	44°	46°	48°	50°	52°
Time for 1°..	7m	6¾m	6½m	6m	6m	5¾m	5½m	5¼m	5m

An example will best illustrate the use of this table, showing the uniform rate of change:

Say a survey is to be commenced in latitude 43° N. when sun is in declination 21° 15′ N., as per Nautical Almanac. Compute sun's amplitude by the well known formula.

Sin. Amp. = sec. lat. × sin. dec.

Thus:

Sec. lat. 43°. — log.	=	10.1359
Sin. dec. 21° 15′ "	=	9.5592
Sin. amp. "	=	9.6951 = 29° 42

Then, as each one degree of change of azimuth requires six minutes of time (see table), we have 179 minutes, or, say three hours of time, in which our amplitude is available for azimuth.

It is best to reduce the amplitude directly to azimuth, when we find the sun rises N. 60° 18′ E., and that it gains in azimuth one degree in each six minutes for three hours, thus giving ample time for determining the azimuth of some of the lines of the survey, whence other bearings may be had from the interjacent angles.

It must be remembered that, in consequence of refraction,

the sun shows himself before he is fairly up. The refraction being something over one-half degree, we must wait till his lower limb is fully one-half the sun's diameter above the horizon, before we take our bearing, as otherwise our line of reference will be too far to the left.

This caution being observed, we have nothing to do with "altitude" or "refraction" to know azimuth to a good degree of precision, quite sufficient for all the purposes of the practical surveyor. But the surveyor must be smart enough to get up before the sun, in order to note the time by watch when the sun rises. If we fail in this, we will incur the labor of some calculation. And if we wish to avail ourselves of this property in the afternoon, we will incur this calculation, any way.

Then, we must know the apparent time of sunrise, which must be deduced from mean local time and the equation of time. This will require a knowledge of the error of our watch on local time. It is best to get up early.

PROF. DAVIS: The title of this paper is the "Expansion of an Amplitude." I think Mr. Pearsons is a little unfortunate in his title. I think it should be "The extension of time for observing the sun for obtaining azimuth," and the paper covers this ground. Where it is possible for a surveyor to see the sun in the horizon at the time of rising, he may very readily get the direction of a line and thus his azimuth, near enough certainly for use with the needle compass, and very likely for the transit.

Now, I had no opportunity to prepare anything in addition to what Mr. Pearsons has to say or I would have gladly done so. He has given us here nothing but the result, which, presented in that brief way, is valuable, and gives no hint as to the amount of labor behind it.

MR. APPLETON: It would seem that there would be a good deal of labor behind that.

PROF. DAVIS: Wherever a surveyor can have a horizon, a large lake lying east of him for instance, he can make this observation very easily. It is easy enough to find the direction of the sun at sunrise.

MR. HODGMAN: That seems to be a very simple matter, then?

PROF. DAVIS: Why, it is a simple matter to use it. You have got to know just the direction at sunrise, and then allow for so much time to get your direction at a later hour.

MR. APPLETON: That is six minutes for every degree.

PROF. DAVIS: That is for this particular case. He gives a table showing that at 36 degrees of latitude it requires seven minutes to make a degree's difference in the direction of the sun, and that only gets to be six minutes from 36 until you get to 42 degrees of latitude. Where it is six minutes of time, it makes a degree difference between the sun's rise. Where you get to 56 degrees it takes five minutes of time to make a degree of difference in the direction of the sun.

COMPUTATION OF R. R. EARTH-WORK AND HAUL.

H. F. BEAN.

EARTH-WORK.

There are several methods of computing earth-work, and perhaps the most common is the average end area method, not that it is the most correct; but this method is easily applied, and in many cases is a close approximation to the true result.

FORMULA FOR AVERAGE END AREAS.

$$A = \frac{l}{2 \times 27}(a' + b') \tag{1}$$

A = cubic yards, l = length of section in feet, a', b' = the areas in feet, of the two parallel ends of the section.

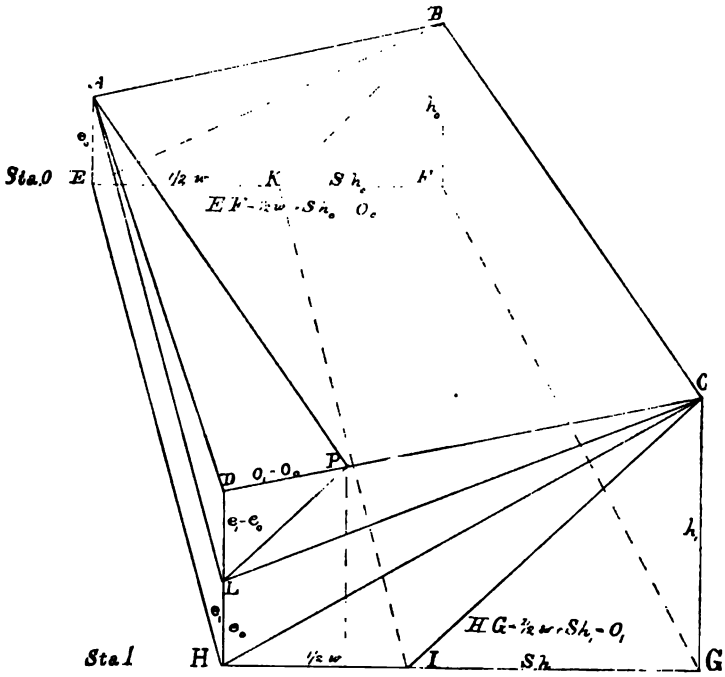
PRISMOIDAL FORMULA.

$$A = \frac{l}{6 \times 27}(a' + b' + 4m) \tag{2}$$

A = cubic yards, l = length of prismoid in feet, a', b' = the areas of the two parallel ends of the prismoid, and m is the area of the middle section parallel with the two ends.

In railroad work, the prismoid is composed of prisms, right

wedges, and pyramids, and as the prismoidal formula will give the true quantities of each separately, it must give the true amount in the prismoid. When $\frac{a^1+b^1}{2} = m$, it may be substituted for m in (2), and reduces to (1), therefore, when the middle area of the prismoid is equal to the half sum of the end areas, formula (1) gives the same result as formula (2).



In the prism and right wedge the half sum of their end areas is equal to their middle areas, and (1) or (2) give the same result. The case is different with the pyramid. In (1), let b^1 = area of the base of a pyramid, $a^1 = o$, and $A_1 = \frac{1}{2}l \times \frac{b^1}{27}$; but $A = \frac{1}{3}l \times \frac{b^1}{27}$ is the correct volume of the pyramid, the difference is $\frac{1}{6}l \times \frac{b^1}{27}$, which is the correction to be subtracted from the amount found by (1). $C = \frac{1}{6}l \times \frac{b^1}{27}$ (7) correction. The base and altitude of the triangle whose area is b^1, (base of pyramid) is found as follows: Let $A\ B\ K\ E$, Fig. 1, represent a cross section of the right half of a section of railroad excava-

tion, and $D\ C\ I\ H$ is another cross section l feet from the first.

Let c_0 and c_1 = center heights.
h_0 and h_1 = side heights.
w = width of roadway.
s = ratio of side slopes.
$o_0 = \frac{1}{2} w + s\, h_0 = E\ F$ = out of first.
$o_1 = \frac{1}{2} w + s\, h_1 = H\ G$ = out of second.
l = length of the section.

The question is to locate the pyramid, and find its base and altitude. Conceive a narrow plane to pass through the points H and C, along the lines $B\ C$ and $E\ H$, through the points B and E; the part cut off, $B\ E\ K - C\ H\ I$, is a triangular prismoid having one of its sides a rectangle ($E\ H\ I\ K$), and the middle area equals one-half the sum of the end areas, and can be computed by (1).

Take $H\ L - A\ E$, and draw the line $A\ L$, and conceive a plane to pass through the points C and L, along the lines $B\ C$ and $A\ L$, through the points A and B, cutting off the triangular prismoid $A\ B\ E - C\ H\ L$, whose side $A\ E\ H\ L$ is a rectangle by construction, and its middle area is one-half the sum of its end areas, and can be computed by (1). Take $M\ G - E\ F$, and erect a perpendicular at M, and produce it to P; draw the lines $A\ P$ and $P\ L$, and conceive a plane to pass through the points P and L, along the lines $A\ P$ and $A\ L$, cutting off the triangular prismoid $C\ P\ L - A\ B$, also the triangular pyramid $D\ P\ L - A$. The prismoid $C\ P\ L - A\ B$ is equal in volume to a right wedge, the area of whose base equals the area of the triangle $C\ P\ L$, and width equal to $E\ F$. Area of $C\ P\ L$ = area $C\ D\ L$ − area of $P\ D\ L$; area of $C\ D\ L = \frac{D\ L \times G\ H}{2} = \frac{(e_1 - e_0) \times O_1}{2}$, and area of $P\ D\ L = \frac{H\ M \times D\ L}{2} = \frac{(e_1 - e_0)(O_1 - O_0)}{2}$. By subtraction $C\ P\ L = \frac{(e_1 - e_0)\, O_0}{2}$. The middle area of the prismoid $C\ P\ L - A\ B$, is equal to the half sum of the two end areas, and can be computed by (1). The pyramid $P\ D\ L - A$ has for the area of its base the area of the triangle $P\ D\ L = \frac{(e_1 - e_0)(O_1 - O_0)}{2} = b'$ in (7). Substitute the value of b' in (7), and we have:

$$(3) \qquad C = \frac{l}{2 \times 27} \frac{(e_1 - e_0)}{6} (O_1 - O_0)$$

Let $\frac{(e_1 - e_0)}{6} (O_1 - O_0) = e^1$, then (4) $C = \frac{l}{2 \times 27} \times e^1$.

$$(1) - (4) = A_1 - C = A = \frac{l}{2 \times 27} (a^1 + b^1 - e^1).$$

$$(5) \qquad A = \frac{l}{2 \times 27} (a^1 + b^1 - e^1)$$

Formula (5) will give the same result as (2). For level cuts and fills, Fig. 1, $h_0 = e_0$, and $h_1 = e_1$, $O_0 = \frac{1}{2} w + s\, e_0$, and $O_1 = \frac{1}{2} w + s\, e_1$. $O_1 - O_0 = (e_1 - e_0)\, s$, which multiplied by two, for both sides, gives $2\ (O_1 - O_0) = 2\ s\ (e_1 - e_0)$, and substituted in (3) for $(O_1 - O_0)$, then—

$$C = \frac{l}{2 \times 27} \frac{(e_1 - e_0)^2}{6} \times 2s = (6)\ C = \frac{l}{2 \times 27} \frac{(e_1 - e_0)^2}{3} s.$$

When the slope is $1\frac{1}{2}$ to 1, $s = 1\frac{1}{2}$, which substituted for s in (6), will give $C = \frac{l}{2 \times 27} \frac{(e_1 - e_0)^2}{2}$, or the factor $\frac{(e_1 - e_0)^2}{2} = e^1$, may be substituted in (5), and give the same result as (1) — (6).

The correction for three level work, center and side heights, is found as follows:

In (3), let O_1 and O_0, each represent the sum of the outs of either end (distance between the slope stakes on top of the cuts, or bottom of the fills).

For five level work, where the levels are taken at the center, foot of the slope (which is distant from the center in cuts, one-half the width of the roadway), and at the outside slope stakes.

In Fig. 1, let h^1 = height at foot of slope at (K), and h^{11} = height at foot of slope (not marked) at (I), then substitute $(h^{11} - h^1)$ for $(e_1 - e_0)$, in (3), will give the correction for one-half of the section, and the other half of the section is corrected in the same manner.

It is generally understood that no formula can be made that will give correct results, where the earthwork has not been properly cross-sectioned. The error of the average end area method may be reduced by taking several cross-sections in each section.

Let n = the number of sub-sections of equal length made from a section l feet in length; then $\frac{1}{n}$ = the fractional part of a section whose length is l, that is represented by the sub-

section. The length in feet of the sub-section is $\frac{1}{n} \times l = \frac{l}{n}$, which substituted in (6) for l (remember that $(e' - e_0)$ decreases in the same ratio as l decreases), and $C_1 = \frac{1}{n^3}\left\{\frac{l}{2} \times 27\frac{(e_1 - e_0)^2}{3}\right\}s$, or $C_1 = \frac{1}{n^3} \times C$. But C is the correction for l feet, and $C \times \left\{\frac{1}{n}\right\}^3 = C_1$, the correction for one sub-section whose length is $\frac{l}{n}$ feet, and as the correction for each sub-section is the same, the correction for n sub-sections is $C \times \left\{\frac{1}{n}\right\}^3 \times n = C \times \left\{\frac{1}{n}\right\}^2 = C_n$. Therefore, we conclude that if any section of earth-work is subdivided into n equal sub-sections, the pyramid correction (error by end area method) decreases in the ratio of C, to $C \times \left\{\frac{1}{n}\right\}^2$, or 1 to $\left\{\frac{1}{n}\right\}^2$. Assume $n = 4$, then $\frac{1}{n} = \frac{1}{4}$, and $(\frac{1}{4})^2 = \frac{1}{16}$, which has eliminated $\frac{15}{16}$ of the error, and if we put $n = 10$, then $\frac{1}{n} = \frac{1}{10}$, and $(\frac{1}{10})^2 = \frac{1}{100}$, or, we have eliminated $\frac{99}{100}$ of the correction (error), so that where the ground is irregular, we not only get a better average of the general surface of the ground, by taking cross sections where the surface of the ground changes; but we nearly eliminate the pyramid correction, and the average end areas will give a result not far from the truth.

Formula (1) is approved by statute to be used upon the public works of the state of New York. When the ridges or hollows run obliquely to the line of roadway, their direction should be marked in the field notes, so that the actual middle area can be calculated, and the prismoid calculated by formula (2). For an exposition of a method used by some, which consists of finding the areas of irregular cross sections and reducing them to level cross sections and applying the prismoidal formula, see Henck's Field Book, pages 109 and 110.

The three following examples will illustrate the method of applying the correction formula. In said examples I have assumed the roadway 20 feet wide with side slopes of $1\frac{1}{2}$ to 1.

The first is level cuttings, second three levels, and the third five levels, all sections 100 feet.

Ex. 1. $\frac{4}{16}$ $\frac{4}{0}$ $\frac{4}{16}$ area $a^1 = 104$.
$\frac{12}{24}$ $\frac{12}{0}$ $\frac{12}{24}$ area $b^1 = 456$.

In (4) $e^1 = \frac{(e_1 e_n)(O_1 O_n)}{6}$.

$$e^1 = \frac{(12-4)(28+28-16-16)}{6}.$$

$$e^1 = 32.$$

(5) $A = (a^1 + b^1 - e^1) \times \frac{l}{2 \times 27}$, $A = \frac{(104+456-32)}{2 \times 27} \times 100 = 977\frac{7}{16}$ cu. yds.

Ex. 3. $\frac{4}{16}$ $\frac{3}{10}$ $\frac{5}{5}$ $\frac{9}{16}$ $\frac{12}{24}$ area $= 236 = a^1$.
$\frac{8}{22}$ $\frac{9}{10}$ $\frac{1}{0}$ $\frac{13}{16}$ $\frac{4}{37}$ area $= 449.5 = b^1$.

In (4) $e^1 = \frac{(22-16)(9-5)+(37-28)(13-9)}{6} = \frac{6 \times 4 + 9 \times 4}{6} = 10.$

(5) $A = \frac{l}{2 \times 27}(a^1 + b^1 - e^1) = \frac{(236+449.5-10)}{2 \times 27} \times 100 = 1250\frac{9}{16}$ yds.

Ex. 2. $\frac{4}{16}$ $\frac{6}{0}$ $\frac{3}{29}$ area $174 = a^1$.
$\frac{12}{25}$ $\frac{12}{0}$ $\frac{14}{31}$ area $456 = b^1$.

In (4) $e^1 = \frac{(12-6)(31+25-16-22)}{6} = \frac{6 \times 18}{6} = 18.$

(5) $A = \frac{l}{2 \times 27}(a^1 + b^1 - e^1) = \frac{(174+456-18)}{2 \times 27} \times 100 = 1{,}133\frac{3}{16}$ yds.

Tables for calculating earth-work are a great saving of time and labor; besides in practice being less liable to error than computing by formula. About twenty years ago I computed an earth-work table which can be used for any slope or base. also for side hill cuts, or fills, ditches, barrow pits, etc.

BEAN'S GENERAL EARTH-WORK TABLE.

Form of the table.—Fig. 2.

Feet.	1	2	3	4	5	6	7	8	9
	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.	Cubic yards.
10.....	9.26	18.52	27.78	37.04	46.30	55.56	64.81	74.07	83.33
20.....	18.52	37.04	55.56	74.07	92.59	111.11	129.63	148.15	166 67
30.....	27.78	55.56	83.33	111.11	138.89	166.67	194.44	222.22	250.00
40.....	37.04	74.07	111.11	148.15	185.19	222.22	259.26	296.30	333.33
50.....	46.30	92.59	138.89	185.19	231.48	277.78	324.07	370.37	416.67
60.....	55.56	111.11	166.67	222.22	277.78	333.33	388.89	444.44	500.00
70.....	64.81	129.63	194.44	259.26	324.07	388.89	453.70	518.52	583.33
80.....	74.07	148.15	222.22	296.30	370.37	444.44	518.52	592.59	666.67
90.....	83.33	166.67	250.00	333.33	416.67	500.00	583.33	666.67	750.00
100.....	92.59	185.19	277.78	370.37	462.96	555.56	648.15	740.74	833.33

The formula from which the table may be computed is found as follows:

In the triangle $B\ E\ F$, Fig. 1, assume $B\ F = C\ G$, and $E\ K = H\ I$ (by construction), then $B\ E\ K - C\ H\ I$ represents

a triangular prism, whose length is l, and volume in cubic yards will $= \frac{EK \times BF \times l}{2 \times 27}$. Let $EK = x$, and $BF = y$, also $\frac{1}{2}\ l = 50$ feet, and A = cubic yards in prism (8) $A = (x \times y)\ \frac{50}{2 \times 27}$, which is the formula required. Let $x = 10$, and $y = 1, 2, 3$, etc., which substituted in (8) will give the cubic yards opposite 10, and under 1, 2, 3, etc., in table, Fig. 2. Again substitute 20 for x, and 1, 2, 3, etc., for y as before, and the cubic yards will be found opposite 20, and under 1, 2, 3, etc.

The table gives the volume in cubic yards for triangular prisms whose lengths are 50 feet, and the base of the prism will be found in the first column under *feet*, and the altitude of its base, is found at the top marked 1, 2, 3, etc., and the cubic yards are found opposite the base, and under the altitude of the triangular base, which is given.

The table may be used for greater or less bases, or altitudes, by changing the decimal point. In the table, Fig. 2, I have given the cubic yards for bases, 10 feet, 20 feet, etc., merely to show how it is constructed; but in my table the first column under feet, commences with $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$ of a foot, and is carried to 50 feet, and the figures at the top of the table are 1, 2, etc., to 20 feet. This table has been used for several years by the M. C. R. R. Co., and they say that it fills the bill.

Example 3, calculated by tables.

$\frac{4}{16}\ \frac{5}{10}\ \frac{7}{0}\ \frac{9}{10}\ \frac{12}{25}$.

$\frac{5}{22}\ \frac{9}{10}\ \frac{13}{0}\ \frac{13}{10}\ \frac{18}{37}$.

By table, Fig. 2.		By large table, the amounts are taken direct for each prism.
16 × 5 =	46.3	74.1
	27.7	
28 × 9	166.7	233.3
	66.7	
20 × 7	129.6	129.6
	437.0	437.0
22 × 9 =	166.7	183.3
	16.7	
37 × 13 =	277.8	445.4
	64.8	
	83.3	
	19.4	
20 × 11 =	185.2	
	18.5	203.7
	832.4	832.4
	437.0	
	1269.4	
	− 18.5	= correction
	1250.9 yards.	

Correction. $\frac{(22-16)(9-5)+(37-28)(13-9)}{3}$ or $\frac{6\times4+9\times4}{3}$ $= 2\times4+3\times4=5\times4$.

Look in table for $5\times4=\frac{50\times4}{10}$ 18.5 yards, which is the correction. If we computed the area of the first cross section the factors would be $\frac{16\times5+28\times9+20\times7}{2}$, and we use the same factors to find the cubic yards by the table, only we do not divide by 2, as we use $\frac{1}{2}$ 50 feet $\frac{1}{3}$ (areas of the same) $\times$ 100.

PROF. COOLEY: Isn't it a fact that the contractor should measure by the average end area method?

MR. BEAN: In the state of New York that is the case. There was some difficulty about canal work and Mr. Hyde said that that was the way they measured it and that was their law there, but the supposition is that the end area method always favors the contractor, but the end area method does not differ so much, only where you have irregular work it is a hard matter to apply the formula. You help the matter by putting the cross sections close together, but no matter if these surfaces are plane, they will give the same value.

PRESIDENT: It is customary on many railroads to state in the specifications not only how the earth-work shall be computed, but as you are all very familiar with the fact that it is frequently stated in the specifications how far the haul shall extend. On the Detroit & Lansing road, in this State (I am sorry Mr. Tuthill is not here to tell us a little more definitely about it), but I think on that road that has been carried to the extent of saying that no haul will be allowed within 1,000 feet from the mouth of the cut. That would require a fill 2,000 feet long before they began any haul.

Are there any other points that you would like to present upon this subject?

MR. BEAN: Just one point in reference to the double track cross section. That is the kind of work that engineers hate, this double track work. Here is an irregular ditch. Want to cross section this—take out more earth or fill it up. Supposing we commence here, [drawing diagram on the blackboard;]

here is the line of level and we will just take a bend in here and draw a tape over here, and just take those levels and give the difference here. Here is the bank up here, and draw a line over here. Now the supposition is that the surface of the ground is something in that shape. Now in my table I compute two of these together. I have the heights and add them together and multiply with this width. If it is the same height, why all right. But supposing you are down here, then this triangle will be subtracted. It is not a very pleasing thing to work out, but you can work it out very well with the table.

PRESIDENT DAVIS: It is a gratification to have one's experience sustained by that of another man. I came to the conclusion that the only table of much use was the multiplication table.

MR. BEAN: When I was an engineer I didn't favor the haul question so much, but when I was a contractor I did favor it and was always willing to get all the haul I could. I know of no place where the rule of "thumb" is used so much as in the question of haul. The same individual hardly ever computes it twice alike himself. I will give you my theory and principle of doing it.

HAUL.

It is generally agreed between the company and contractor, that all earth hauled within a certain distance, which distance is called the limit of free haul, is paid for at a stipulated price, being included in the price paid for excavation, and for all earth hauled beyond that limit an additional price per yard for each 100 feet hauled will be paid. There is another limit of haul also, and that is when the price paid for the extreme haul equals the price paid for excavation, in which case the contractor is allowed to barrow and waste. The theory of calculating haul is not difficult; but in practice it is not so easy a matter. To find the points of free haul in excavation and embankment:

Let f = number of stations of free haul (100 feet each).

Select the points in cut and fill so that $(f - 1)$ stations of

the free haul nearly balance in excavation and embankment, with a difference of $\pm d$ yards of embankment.

Let x = additional distance to excavate the cut.
$100 - x$ = length of fill to balance the f stations.
m = cubic yards in one station of additional cut.
n = cubic yards in one station of additional fill.

$$\frac{m\,x}{100} \quad (100 - x)\,\frac{n}{100} \pm d.$$

(9) $$x \quad \frac{100\,(n \pm d)}{m + n}$$

This is a close approximation, as x will be taken for the nearest whole feet. If an allowance for shrinkage or increase in excavation is required, change the value of m in (9). Assume that the excavation shrunk 10 %, substitute for m, in (9), $\frac{9}{10}\,m$.

The center of gravity formula seems to be the most correct principle for computing haul, and it is the only method that I shall discuss.

The prismoidal formula is based upon the assumption that the prismoid is composed of prisms, right wedges and pyramids, but it will give the correct volume of each separately; therefore, it will give the correct volume when two or more are taken together. I will make the same assumption in order to deduce the gravity formula, and must subdivide the prismoid into its prisms, right wedges and pyramids, and find the center of gravity of each, and from them the center of gravity of the prismoid.

Let A = cubic yards in a prismoid of earth.
P = cubic yards in its prisms.
W = cubic yards in its right wedges.
p = cubic yards in its pyramids.
H = center of gravity (haul) from the least cross section.
H_1 = center of gravity (haul) from the greater cross section.
l length of prismoid (100 feet).

From mechanics we learn that center of gravity $\frac{1}{2}\,l$ for the prism; $\frac{2}{3}\,l$ for the right wedge from edge, or $\frac{1}{3}\,l$ from base; $\frac{3}{4}\,l$ for pyramid from vertex, or $\frac{1}{4}\,l$ from base.

$A = P + W + p.$

$$H = \frac{\frac{1}{2}\,l \times P + \frac{2}{3}\,l \times W + \frac{3}{4}\,l \times p}{P + W + p} = \frac{l\,(\frac{1}{2}\,P + \frac{2}{3}\,W + \frac{3}{4}\,p)}{A}$$

$$H_1 = \frac{\frac{1}{2}\,l \times P + \frac{1}{3}\,l \times W + \frac{1}{4}\,l \times p}{P + W + p} = \frac{l\,(\frac{1}{2}\,P + \frac{1}{3}\,W + \frac{1}{4}\,p)}{A}$$

$$H = \frac{l\,(\frac{1}{2}\,P + \frac{2}{3}\,W + \frac{3}{4}\,p)}{A} \tag{10}$$

$$H_1 = \frac{l\,(\frac{1}{2}\,P + \frac{1}{3}\,W + \frac{1}{4}\,p)}{A} \tag{11}$$

Having given the cubic yards in a prismoid (A), to find the cubic yards in the prism (P), wedge (W), and pyramid (p), which compose the prismoid, and when substituted in (10), or (11), will give the center of gravity (haul) from either end of the prismoid. In (5) $A = \frac{l}{2 \times 27}\,(a^1 + b^1 + e^1) = \frac{l}{2 \times 27} \times a^1 + \frac{l}{2 \times 27} \times b^1 + \frac{l}{2 \times 27} \times e^1$. Let $a = \frac{l}{2 \times 27} \times a^1$, $b = \frac{l}{2 \times 27} \times b^1$, and $e = \frac{l}{2 \times 27} \times e^1$.

(12.) $A = a + b + e$, (volume in cubic yards). Assume $a = b$, the prismoid is a prism, and e = zero. $A = a + a = 2a = P$, the prism. In (7) $\frac{1}{6}\,l \times \frac{b^1}{27}$ correction; but $\frac{1}{3}\,l \times \frac{b^1}{27}$ volume of pyramid, whose altitude is l feet, and area of base b^1 feet, therefore the correction is one-half of the pyramid, and $p = 2e$, $P = 2a$, and as $P + W + p = A$, $W = A - P - p$, or $W = A - 2a - 2e$. Substitute these values for P, W, and p, in (10) and (11) and reduce we have (13) and (14).

$$H = \frac{l\,(A + b - e)}{3A}, \tag{13}$$

which is the distance from center of gravity from the lesser cross section ($a = b$).

$$H_1 = \frac{l\,(A + a - e)}{3A}, \tag{14}$$

which is the distance of center of gravity from the greater cross section.

$$\frac{(13) + (14)}{2} = \frac{l\,(2A + a + b - e)}{6A} = \frac{l\,(3A)}{6A} = \frac{l}{2} \tag{19}$$

$$\frac{(13) - (14)}{2} = \frac{l\,(A + b - \frac{1}{2}e - A - a + \frac{1}{2}e)}{6A} = \frac{l\,(b - a)}{6A} \tag{20}$$

(15) $H = l\left(\frac{1}{2} + \frac{b-a}{6A}\right)$ by addition.

(16) $H_1 = l\left(\frac{1}{2} + \frac{a-b}{6A}\right)$ by subtraction.

(15) and (16) gave the average haul.

(17) $H \times A = l\left(\frac{1}{2}A + \frac{b-a}{6}\right)$.

(18) $H_1 \times A = l\left(\frac{1}{2}A + \frac{a-b}{6}\right)$.

(17) and (18) gives the entire haul to move the earth to either cross section.

In (12) $A = a + b - e$, remember that a and b represent the half volumes of prisms, and if $a = b$, and $e = o$, $A = 2a$, and $2b = P$; but the wedge is one-half the prism of the same altitude and base, then $\frac{1}{2} P = b$, volume of wedge, and as the pyramid equals one-third the volume of the prism of the same altitude and base, then $\frac{1}{3} \times P = \frac{1}{3} \times 2b =$ volume of pyramid.

In (15) $H = l\left(\frac{1}{2} + \frac{b-a}{6A}\right)$, let $a = b$, then $H = \frac{1}{2} l$ center of gravity of prism. Let $a = o$, then the half prism b is a wedge, and $A = b$ which substituted in (15) for A gives $H = l\left(\frac{1}{2} + \frac{b}{6b}\right) = l\left(\frac{1}{2} + \frac{1}{6}\right) = \frac{2}{3} l$, or $\frac{1}{3} l$ in (16), which is the center of gravity of the right wedge. Again, for the pyramid $A = \frac{1}{3} \times P = \frac{1}{3} \times 2b = \frac{2}{3} b$, which substituted in (15) for A, gives $H = l\left(\frac{1}{2} + \frac{b}{4b}\right) = l\left(\frac{1}{2} + \frac{1}{4}\right) = \frac{3}{4} l$, or $\frac{1}{4} l$ in (16), which is the center of gravity of the pyramid, (15) and (16) fills the bill, because it gives the center of gravity of the prism, right wedge and pyramid, each separately, and must give the center of gravity of the prismoid. (13) and (14) will give the same result. (17) and (18) is the average haul multiplied by the number of yards and gives the total distance that one yard is hauled, and if l = one station (100 feet), the distance will be given in stations. Let l = one station, and let A, b and a, in cubic yards, be substituted in (17) and (18), and the result will be the number of yards hauled one station, or the number of stations one yard is hauled to move the earth in the section to either cross section. (13) and (14), $\frac{H + H_1}{2} \frac{l}{2} = \frac{1}{2}$ sum.

$\frac{H - H_1}{2} = \frac{l}{6}\left(\frac{b-a}{A}\right) = \frac{1}{2}$ difference.

In (19) $\frac{H + H_1}{2} = \frac{l}{2}$ the sum of the distances of the center of gravity of the prismoid from each end (center of prismoid).

In (20) $\frac{H - H_1}{2} = \frac{l}{6}\left(\frac{b-a}{A}\right) =$ the distance of the center of gravity from the middle cross section of the prismoid, and $\frac{l}{2} - \frac{l}{6}\left(\frac{b-a}{A}\right)$ expresses the distance of the center of gravity from either end of the prismoid, and is given separately in (15) and (16).

In (12), $a = \frac{l}{2 \times 27} \times a'$ in (1), and $b = \frac{l}{2 \times 27} \times b'$, substitute these values for a, and b in (20) and reduce, which gives (21) $\frac{H - H_1}{2} = \frac{l^2(b' - a')}{12 \times 27 A}$. Again, if we substitute in (21) $A_1 = \frac{l}{2 \times 27}(a' + b')$, (1) for A, and reduce, we have (22), $\frac{H - H_1}{2} = \frac{l}{6}\left(\frac{b' - a'}{a' + b'}\right)$. Let $\frac{H - H_1}{2} = x$, and $A = s$, then (21) and (22) are identical with (360) and (361) in Searle's Field Engineering, page 244.

Now, (22) is a close approximation, but is not theoretically correct; because A_1, which was substituted for A, was obtained from (1). The correct value of A, given in (5), $A = \frac{l}{2 \times 27}(a' + b' - e')$, substituted in (21), gives the correct result in (23) $\frac{H - H_1}{2} = \frac{l}{6}\left(\frac{b' - a'}{a' + b' - e'}\right)$. Formula (23) expresses the distance of the center of gravity of a prismoid, from its middle section, in terms of its length, end areas, and end area correction. Formula (20) gives the same result, but a, b and A represent cubic yards, and may be taken from a table, or computed.

Formula (17) and (18) will give the distance to haul one yard, to be equivalent to hauling all of the earth to either cross section of a section of earth-work whose length is l. If $a < b$, and the earth is hauled toward a, use (17); but if hauled toward b, use (18).

A formula to compute the haul of several sections of earth work, or a whole cut or fill at once, is found as follows:

Let station o a_o = (area of cross section at station o) $\times \frac{100}{2 \times 27}$ $\frac{1}{2}$ vol.
" " 1 a_1 = (" " " " " " 1) " "
" " 2 a_2 = (" " " " " " 2) " "
" " 3 a_3 = (" " " " " " 3) " "
" " n a_n = (" " " " " " n) " "
" " A_1 = cubic yards in section 1.
" " A_2 = " " " " 2.
" " A_3 = " " " " 3.
" " A_n " " " " n.
" " H_1 = haul of section 1, all earth hauled to station 1.
" " H_2 = " " " 2, " " " " " " 2.
" " H_3 = " " " 3, " " " " " " 3.
" " H_n " " " n, " " " " " " n.
" " S_n^o = total haul of n sections hauled from 0, 1, 2, etc., to station n.
" " l = 1 station = 100 feet.
" " e_1 = correction of pyramid in section 1.
" " e_2 = " " " " " " 2.
" " e_3 = " " " " " " 3.
" " e_n = " " " " " " n.

Total haul of section 1, to station n $H_1 \times A_1 = (n - 1) A_1 + \frac{1}{2} A_1 + \frac{a_o - a_1}{6} + (n - 1) A_1$.

Total haul of section 2, to station n $H_2 \times A_2 = (n - 2) A_2 + \frac{1}{2} A_2 + \frac{a_1 - a_2}{6} + (n - 2) A_2$.

Total haul of section 3, to station n $H_3 \times A_3 = (n - 3) A_3 + \frac{1}{2} A_3 + \frac{a_2 - a_3}{6} + (n - 3) A_3$.

Total haul of section $n - 1$, to station n $H_{n-1} \times A_{n-1} = (n - n + 1) A_{n-1} + \frac{1}{2} A_{n-1} + \frac{a_{n-2} - a_{n-1}}{6} + A_{n-1}$.

Total haul of section n, to station n $H_n \times A_n = (n - n) A_n + \frac{1}{2} A_n + \frac{a_{n-1} - a_n}{6}$.

By addition we have,

(24) $S_n^o = (n - 1) A_1 + (n - 2) A_2 + \ldots (n - n + 1) A_{n-1} + \frac{1}{2} [(A_1 + A_2 + \ldots (n - n + 1) A_{n-1} + A_n)] + \frac{a_o - a_n}{6}$.

(25) $S_n^o = (n - \frac{1}{2}) A_1 + (n - \frac{3}{2}) A_2 + \ldots (n - n + \frac{1}{2}) A_{n-1} + \frac{1}{2} A_n + \frac{a_o - a_n}{6}$.

Example 4.

Stations.	Cubic yards.	Cubic yards.	e	Cubic yards in stations.	
0	a_0				
1	a_1	$a_0 + a_1$	$-e_1$	A_1	A_1
2	a_2	$a_2 + a^1$	$-e_2$	A_2	$A_1 + A_2$
3	a_3	$a^3 + a_2$	$-e_3$	A_3	$A_1 + A_2 + A_3$
4	a_4	$a_4 + a_3$	$-e_4$	A_4	$A_1 + A_2 + A_3 + A_4$
$n-1$	a_{n-1}	$a_{n-1} + a_{n-2}$	$-e_{n-1}$	A_{n-1}	$A_1 + A_2 + \ldots A_{n-1}$
n	a_n	$a_n + a_{n-1}$	$-e_n$	A_n	

Example 5.

Stations.	Cubic yards.	Cubic yards.	e	Cubic yards in stations.	Haul (o to n) of whole sections.
0	200				
1	600	800	−10	790	790
2	1000	1600	−30	1570	2360
3	900	1900	−20	1880	4240
4	800	1700	20	1680	5920
5	1200	2000	−30	1970	7890
6	1600	2800	−40	2760	
				2)10650	21200
	200	$\frac{1}{2}A_1 + A_2 + \ldots A_{n-1}$		$= 5325$	5325
	−1600				26525
	6)−1400	$\frac{a_0 + a_n}{6}$			$-233\frac{1}{3}$
	$-233\frac{1}{3}$				$26291\frac{2}{3}$ = yards hauled one station. Cost of haul at .01 per yard per station, $262.91\frac{2}{3}$.
1	2	3	4	5	6

In example (5), assume station six to be the limit of free haul in excavation, the numbers represented in columns two, three, etc., marked at the bottom, the cubic yards tabulated as usual from cross section notes. Column five contains the cubic yards in each section, and 21200, the sum of column six, is the number of stations to haul one yard, which is equivalent to hauling the earth in section one, from station one to station six, hauling section two from station two to section six, etc., and may be calculated by the first part of (24), by substituting six for n, and we have $5\,A_1 + 4\,A_2 + \ldots A_5$. One-half the sum of column five gives the number of stations to haul one

yard, to haul the earth in each station to either cross section, assuming that each section is hauled one-half station as shown in (24), $\frac{1}{2}(A_1 + A_2 + \ldots . A_n)$. Column two is used to make the correction for the assumption that the center of gravity lies in the middle cross section of each section, and is found in the last factor in (24). $\frac{a_n - a_1}{6} = \frac{200 - 1600}{6} = -233\frac{1}{3}$ cubic yards hauled one station, which is to be deducted from the haul calculated from the center of each section. When the factor in (24), $\frac{a_n - a_n}{6}$ o, there is no correction, as all intermediate cross sections have canceled, the haul computed from the middle of each section is correct. Here is where the utility of formula (24) lies, as we are not obliged to find the center of gravity of each section. Compute the haul from the middle of each section, and consider only the first and last cross section to make the correction, as shown in example (5).

Having computed the haul for the cut, the haul for the fill is computed in the same way, from the point of free haul in the embankment, the sum of the hauls of cut and fill is the total haul. It is no object to find the average haul in order to find the cost of haul; but it is found by dividing the total haul by the number of yards hauled. In the example given I took whole sections only, and this would never occur in practice; but I should first make the computation for all of the whole sections between the points of free haul and the extreme haul in both ends and fills, regardless of all plus stations, and then correct those plus sections by (17) if necessary. Having given the number of yards in a full section to find the number of yards in any of its sub-sections. In (12) $A = a + b - e$. I have shown that $P = 2a$, $p = 2e$, and $W = A - 2a - 2e$. Now, similar prisms are to each other as their length, similar wedges as the square of their lengths, and similar pyramids as the cube of their lengths. Let x = length of a prismoid that contains these solids, and let P, W and p represent their volumes. The volume for x feet in length of each, $P x$ = cubic yards in prism, $W x^2$ in wedge, and $p x^3$ in pyramid. Their sum = $P x + W x^2 + p x^3$ (26) $A' = ((p \times x + W) x + P) x$. Take section one in example five, and find the number of yards in

forty feet off the smallest end of the section. Remember that x is the distance from the lesser cross section of the prismoid, and if x feet is required from the greater cross section, substitute $l - x$ for x. Let $x = \frac{40}{100} = \frac{4}{10}$ of a station in length, $a = 200$, $b = 600$, $c = 10$, and $A = 790$. Then $P = 2a = 400$, $p = 2c = 20$, and $W = 790 - 400 - 20 = 370$. Substitute these values in formula (26) $A' = 220\frac{1}{2}$ yards. This gives the volume without the cross section, and is very convenient to find the number of yards in the sub-sections adjacent the points of free haul in excavation and embankment, and the extreme limits of haul in the same.

In conclusion I wish to say that if any member of this society has a better method of calculating haul than this, I would be pleased to have him discuss it before the society, and have the method published, as I wish to be posted on the best practical method in use. This is a branch of calculation in engineering that most engineers dislike, and generally each one has a different method of computing haul, and what is still worse, they cannot compute it twice alike for the same problem.

PRESIDENT: I would say that Mr. Bean has here, in his equation No. 2, what may be designated as the Prismoidal Graphical process. From the bottom up, as Col. Muenscher says. Mr. Bean has arrived at it from the top down, and the part which interests me is the part which he has tabulated there. I want to see that in print, where I can work it over to my own satisfaction. I have been using a different method, a graphical method, easy to apply, if put on cross section paper, but I shall be glad to get hold of that and compare it with my graphical process, and I hope it is enough better so I shall be able to throw the graphical method into the waste basket.

There are a number of men in the room, familiar with this question. Should be glad to hear from you, gentlemen.

MR. BEAN: That little question of haul is easier in theory than in practice; especially when you are brought up in a big law suit and they want you to swear the haul is computed correctly.

COL. MUENSCHER: In our road we never have any contractors, and never have any law suits.

MR. TUTHILL: As far as I am concerned I have had but little experience. Mr. McVean practically eliminates that by saying all hauls shall be 1,500 feet from the mouth of the cut.

PRESIDENT DAVIS: The last time I heard from Mr. McVean it was only 1,000 feet. Present my compliments and say I think he will eliminate this difficulty.

MR. BEAN: My impression is that the easiest way to dispose of that question of haul, is to specify in the contract. It makes it easy for the engineer, but if he is a contractor he will look on the other side. Years ago, the way the work was let, they had a short free haul, and after that they were paid for haul, and of course you would be paid for excavation and embankment. If you haul cuts into fills, you make two yards for the company for every yard of cut hauled, and should be paid for it.

But here is another question. The railroad company reserves the right to change the grade. Now supposing you have a piece of work, and the profile shows you have 5,000 yards in excavation and 10,000 yards in fills, made from cuts and borrowed earth. The company reserves the right to change the grade. It is the easiest thing in the world to change the grade and increase the haul. But in the provision for haul, you should be paid for cut and fill, then if changes do occur, you will be protected. It is the only fair way to take contracts, but it is much easier for engineers to throw the haul out entirely.

EASEMENT CURVES.

E. W. MUENSCHER.

In a paper presented at the last meeting of this society, the writer described a method which he had devised for his own use for setting out an easement curve, and endeavored to show that by the simple expedient of adopting a uniform length of 200 feet for the curve, the formulas for calculating its elements become so simplified that any engineer who is capable of laying

out an ordinary circular curve can carry them in his head, and can apply them in laying out the easement without the use of any of the complicated tables which form an essential feature of all other methods which have fallen under his notice, and that thus what has heretofore been the most serious obstacle to the more general use of this very valuable expedient is practically removed.

This method, while professedly only approximately correct, is so nearly exact that for all cases where the curve to be flattened does not exceed 10° or 12°, the error is practically inappreciable. As this will cover fully ninety-nine cases out of one hundred that occur in practice, and as, for convenience in retracing these curves in the future, it is the best policy to use a uniform system throughout the entire length of a road, it would seem that there would seldom be occasion for the use of any more complicated method. To meet this one-hundredth case, however, and to provide for a very convenient application of easement curves in which a uniform length cannot be used, it is proposed to show in this paper that the principle of the method is general, and can, with but little sacrifice of accuracy and simplicity, be applied to easement curves of any length likely to be employed in practice. For this purpose it will be necessary to repeat a portion of the former paper, which will perhaps be the more excusable as it will serve to present the whole matter in a compact form.

Let l = length of easement curve in feet.
L = " " " " " stations of 100 feet.
Δ = central angle of easement curve.
D = degree of curvature of central curve.
R = radius of central curve.
S = shift of central curve, or the distance it must be moved in toward the center.
X = the abscissa of any point on the easement curve.
Y = the ordinate " " " " " " "
O = " " " the terminal point (or $P\ C\ C$).
e = elevation in feet of the outer rail on the central curve.
i = distance in feet in which the outer rail rises one foot.

The initial point of the easement curve, or the point at which it leaves the tangent (which we will call the $P\ T\ C$), is taken as the origin, and the tangent produced as the axis of co-ordinates, *i. e.*, the abscissa, X, is measured from the $P\ T\ C$ along the tangent, and the corresponding ordinate, Y, is measured from the extremity of the abscissa at right angles to the tangent.

To express the properties of the form of curve which has been found to be best adapted to our purpose we take from Rankine's Civil Engineering the following formulas:

$$Y = \frac{4\ O\ X^3}{l^3} \tag{1}$$

$$\tfrac{1}{2}\ l = \sqrt{6\ O\ R} \tag{2}$$

$$S = \frac{l^2}{24\ R} \tag{3}$$

Combining equations (1) and (2) we obtain.

$$Y = \frac{X^3}{6\ l\ R} \tag{4}$$

and since when $y = O$.. $X = l$, very nearly, we have

$$O = \frac{l^2}{6\ R} \text{ evidently} = 4\ s. \tag{5}$$

We also have

$$R = \frac{5730}{D} \tag{6}$$

$$L = \frac{l}{100} \tag{7}$$

and

$$l = 100\ L. \tag{8}$$

In this form of curve one-half its length lies on each side of the original $P\ C$ of the central curve, and it is tangent at one end to the original tangent, and at the other to the shifted central curve. Hence it follows that the easement curve takes the place of one-half its own length of the central curve, its origin (or $P\ T\ C$) is at a distance from the original $P\ C$ equal to $\frac{1}{2}\ l$, and its central angle (or the angle between the tangents at its extremities), equals the central angle of half its length of the central curve. Hence we have

$$\Delta = \tfrac{1}{2}\ L\ D \quad (9) \quad = \tfrac{1}{2}\ D\ \frac{l}{100} \tag{10}$$

$$D = \frac{2\ \Delta}{L} \quad (11) \quad = \frac{200\ \Delta}{l} \tag{12}$$

$$L = \frac{2\ \Delta}{D}. \tag{13}$$

To express the proper relations between the length of the curve and the slope of the rail we have

$$l = e\ i. \tag{14}$$

In the former paper it was assumed that the maximum value of e in practice is $\frac{2}{3}$ feet, or 8 inches. This is the limit adopted by the Roadmasters' Association at one of its meetings, it is sufficient for a velocity of 50 miles per hour on a 5° curve, of 35 miles per hour on a 10° curve, and of 25 miles per hour on a 20° curve, and a prudent locomotive engineer would seldom venture to exceed these limits. The minimum value of i was taken at 300 feet (equivalent to one inch rise in 25 feet) as recommended by Rankine. Substituting these values in equation (14) we obtain

$$l = 200. \tag{15}$$

Substituting in equations (4), (5) and (3) the values of l in (15), and of R in (6), we obtain:

$$Y = \frac{X^3 D}{6,878,000} \tag{16}$$

$$O = 1.164\ D \quad (= \tfrac{7}{6} D \text{ very nearly.}) \tag{17}$$

$$S = 0.291\ D. \tag{18}$$

From equation (16) it appears that the ordinates, or offsets from the tangent, to intermediate points of the curve are proportional to the cubes of the abscissas, the easement curve differing in this respect from a circular curve, in which, within moderate limits, the ordinates are as the squares of the abscissas as expressed by the formula:

$$q = \tfrac{1}{2} L^2 D. \tag{19}$$

Hence, having O, from equation (17), these ordinates are easily calculated for all other points. Making the abscissa, or the value of X in equation (16), successively $\frac{1}{8}l$, $\frac{1}{4}l$, $\frac{3}{8}l$, $\frac{1}{2}l$, $\frac{5}{8}l$, $\frac{3}{4}l$, $\frac{7}{8}l$ and l, which gives points at intervals of 25 feet, we obtain the following table of the values of the offsets:

TABLE I.

Abscissa	$\frac{1}{8}l$ 25 ft.	$\frac{1}{4}l$ 50 ft.	$\frac{3}{8}l$ 75 ft.	$\frac{1}{2}l$ 100 ft.	$\frac{5}{8}l$ 125 ft.	$\frac{3}{4}l$ 150 ft.	$\frac{7}{8}l$ 175 ft.	l 200 ft.
Ordinate	$\frac{1}{512}O$	$\frac{1}{64}O$	$\frac{27}{512}O$	$\frac{1}{8}O$	$\frac{125}{512}O$	$\frac{27}{64}O$	$\frac{343}{512}O$	O
For $l = 200$	.00227 D	.018 D	.061 D	.145 D	.284 D	.491 D	.779 D	1.164 D
General	.00454 S	.036 S	.122 S	.291 S	.568 S	.982 S	1.558 S	2.328 S

These offsets are easily calculated in the field, and may be

used for setting out the curve, but are more useful for setting over the stakes of a line which has been already located in the usual manner, and into which it is desired to introduce an easement before the grading is done or the cross section stakes set, a case which may often occur. For this purpose the following table will be convenient, in which column four is calculated by equation (19) and column five is the difference between three and four:

TABLE II.

Distance of point from *P T C.*		Offset.			
		Tangent to easement.	Tangent to original line.	Original line to easement.	
1	2	3	4	5	6
$\frac{1}{8}\,l$	25 feet.	.00227 *D*	0.0	0.00227 *D*	$0.00454\frac{\Delta}{l}$
$\frac{1}{4}\,l$	50 "	.018 *D*	0.0	0.018 *D*	$0.036\frac{\Delta}{l}$
$\frac{3}{8}\,l$	75 "	.061 *D*	0.0	0.061 *D*	$0.123\frac{\Delta}{l}$
$\frac{1}{2}\,l$	100 "	.145 *D*	0.0	0.145 *D*	$0.291\frac{\Delta}{l}$
$\frac{5}{8}\,l$	125 "	.284 *D*	0.054 *D*	0.230 *D*	$0.460\frac{\Delta}{l}$
$\frac{3}{4}\,l$	150 "	.491 *D*	0.218 *D*	0.273 *D*	$0.546\frac{\Delta}{l}$
$\frac{7}{8}\,l$	175 "	.779 *D*	0.491 *D*	0.288 *D*	$0.576\frac{\Delta}{l}$
l	200 "	1.164 *D*	0.873 *D*	0.291 *D*	$0.582\frac{\Delta}{l}$

All other points on the central curve must be moved in 0.291 *D*, and it will be sufficiently correct for the grading to use 0.3 *D*, which is very easily remembered.

The easiest and best method of setting out the curve is by deflection angles with the transit. Supposing the transit setting at the *P T C* and calling the deflection angle from the tangent to any point on the curve a, we have evidently

$$\text{Tang. } a = \frac{Y}{X} = \frac{X^3}{6\,l\,R} \div X = \frac{X^2}{6\,l\,R} = \frac{X^2\,D}{3438\,l}. \qquad (20)$$

For the terminal point of the curve (or $P\ C\ C$) since $X = l$, very nearly, and $l = 200$, we have

$$\text{Tang. } a = .05817\ D. \tag{21}$$

$$a = 0.20'' \times D = \tfrac{1}{3}D'. \tag{22}$$

Since, when $l = 200$, equation (10) gives $\Delta = (\frac{1}{2}\ D \frac{l}{100})$ $= D$, the deflection from the chord to the tangent at the $P\ C\ C$ must be equal to $D - \frac{1}{3}\ D = \frac{2}{3}\ D$. From equation (20) it appears that tangent a varies as x^2 and D, and since, for such values of a as would be likely to occur in practice, an angle varies very nearly as its tangent, we may say without appreciable error that the deflection angle from the tangent at the $P\ T\ C$ to any point on the easement curve will vary directly as the degree of curvature of the central curve and as the square of the distance of the point from the $P\ T\ C$. By this principle we may very easily calculate in the field the deflections for intermediate points, and no table is essential, but a little time may sometimes be saved by the use of the following table of values of a:

TABLE III.

Distance of point from P T C.		Value of a, or deflection angle.								
		General.	$D = 1°$	$D = 2°$	$D = 3°$	$D = 4°$	$D = 5°$	$D = 6°$	$D = 8°$	$D = 10°$	$D = 12°$
$\frac{1}{8}\,l$	25 feet.	$\frac{1}{100}\,D°$	0° 0′ 15″	0° 0′ 30″	0° 0′ 45″	0° 1′ 0″	0° 1′ 15″	0° 1′ 30″	0° 2′ 0″	0° 2′ 30″	0° 3′ 0″
$\frac{1}{4}\,l$	50 "	$\frac{1}{400}\,D°$	0° 1′ 0″	0° 2′ 0″	0° 3′ 0″	0° 4′ 0″	0° 5′ 0″	0° 6′ 0″	0° 8′ 0″	0° 10′ 0″	0° 12′ 0″
$\frac{3}{8}\,l$	75 "	$\frac{3}{900}\,D°$	0° 2′ 15″	0° 4′ 30″	0° 6′ 45″	0° 9′ 0″	0° 11′ 15″	0° 13′ 30″	0° 18′ 0″	0° 22′ 30″	0° 27′ 0″
$\frac{1}{2}\,l$	100 "	$\frac{1}{100}\,D°$	0° 4′ 0″	0° 8′ 0″	0° 12′ 0″	0° 16′ 0″	0° 20′ 0″	0° 24′ 0″	0° 32′ 0″	0° 40′ 0″	0° 48′ 0″
$\frac{5}{8}\,l$	125 "	$\frac{5}{1600}\,D°$	0° 5′ 37″	0° 11′ 15″	0° 16′ 52″	0° 22′ 30″	0° 28′ 7″	0° 33′ 45″	0° 45′ 0″	0° 56′ 15″	1° 7′ 30″
$\frac{3}{4}\,l$	150 "	$\frac{3}{400}\,D°$	0° 6′ 45″	0° 13′ 30″	0° 20′ 15″	0° 27′ 0″	0° 33′ 45″	0° 40′ 30″	0° 54′ 0″	1° 7′ 30″	1° 21′ 0″
$\frac{7}{8}\,l$	175 "	$\frac{7}{1600}\,D°$	0° 7′ 52″	0° 15′ 45″	0° 23′ 37″	0° 31′ 30″	0° 39′ 22″	0° 47′ 15″	1° 3′ 0″	1° 18′ 45″	1° 34′ 30″
l	200 "	$\frac{1}{50}\,D°$	0° 8′ 0″	0° 16′ 0″	0° 24′ 0″	0° 32′ 0″	0° 40′ 0″	0° 48′ 0″	1° 4′ 0″	1° 20′ 0″	1° 36′ 0″

When the curve is to be set in from the *P C C* toward the *P T C* the necessary deflections are given in the following table:

TABLE IV.

Distance from P C C.	*Deflection angle.*
$\frac{1}{8}\ l$ = 25 feet	$\frac{3}{192}\ D.$
$\frac{1}{4}\ l$ = 50 "	$\frac{12}{192}\ D = 13\frac{1}{4}' \times D.$
$\frac{3}{8}\ l$ = 75 "	$\frac{63}{192}\ D.$
$\frac{1}{2}\ l$ = 100 "	$\frac{80}{192}\ D = \frac{5}{12}\ D.$
$\frac{5}{8}\ l$ = 125 "	$\frac{95}{192}\ D.$
$\frac{3}{4}\ l$ = 150 "	$\frac{112}{192}\ D = \frac{7}{12}\ D.$
$\frac{7}{8}\ l$ = 175 "	$\frac{119}{192}\ D.$
l = 200 "	$\frac{128}{192}\ D = \frac{2}{3}\ D.$

As these deflections are not easily remembered or calculated except those for the 100 and 200 feet points ($\frac{5}{12}\ D'$ and $\frac{2}{3}\ D'$) it will be most convenient to set only these two points from the *P C C*, and any other necessary points from the *P T C*.

It sometimes happens that the *P T C* is inaccessible. In this case set up at the *P C*, 100 feet (or $\frac{1}{2}\ l$) farther forward on the tangent, deflect $\frac{2}{3}\ D$ from the tangent measure 100 feet and set the *P C C*, then set at the *P C C* and deflect $\frac{1}{3}\ D'$ from the chord, which will give the tangent. If the *P C C* cannot be set from the *P T C*, we may use the above method, or we may first set the middle point of the easement curve, and then set the *P C C* from this point. The deflections will be the following, as may readily be deduced from Tables III and IV:

Transit at *P T C* vernier reading 0° on tangent.

Deflect $\frac{1}{12}\ D'$, vernier reading $\frac{1}{12}\ D'$, gives chord to middle point.

Transit at middle point on chord produced.

Deflect $\frac{3}{12}\ D'$, vernier reading $\frac{3}{12}\ D'$, gives tangent at middle point.

Deflect $\frac{4}{12}\ D'$, vernier reading $\frac{3}{12}\ D'$, gives chord to *P C C*.

Transit at *P C C* on chord produced.

Deflect $\frac{3}{12}\ D'$, vernier reading D', gives tangent at *P C C*.

General Case.

We now propose to show that the principle obtained above is general, and may be applied to any length of easement curve within ordinary limits of practice.

In equations (5), (3), (20), (21) and (22), substitute the values of R, l and D from equations (6), (8) and (11) and we obtain

$$0 = 0.291\ L^2\ D. \quad (23) \quad = 0.582\ l\ \Delta. \tag{24}$$

$$S = 0.0727\ L^2\ D. \quad (25) \quad = 0.1454\ l\ \Delta. \tag{26}$$

$$\text{Tang. } a = \frac{X^2\ \Delta}{1719000\ L^2}. \tag{27}$$

$$\text{Tang. } a \text{ for } P\ C\ C = 0.005817\ \Delta. \tag{28}$$

$$a \text{ " } P\ C\ C = 0^\circ\ 20' \times \Delta = \tfrac{1}{3}\ \Delta^\circ. \tag{29}$$

These equations being precisely analogous to (17), (18), (20), (21) and (22) it follows that the same principle governs in both cases, and Tables I, II, III and IV, may be used for any length of curve, except that in Table I the first, third and fifth lines should be used, and in Table II the first and sixth columns, while in Tables III and IV the only change necessary is to substitute Δ for D. For convenience either in using these tables or in calculating them in the field, the curve should be divided into eight or four equal parts.

The difference between an easement curve of this form and a circular curve may now be very easily expressed. Supposing in each case the transit to be set at the origin of the curve, in a circular curve we deflect from the tangent $\frac{1}{2}$ the central angle to fix the other end of the curve, and at the other end deflect the remaining $\frac{1}{2}$, and the deflections to intermediate points on the curve vary as their distances from the origin. In the easement curve the deflection from the tangent at the origin to the other end is $\frac{1}{3}$ the central angle, and at the other end the remaining $\frac{2}{3}$ is turned, and the deflections to intermediate points vary as the squares of their distances from the origin. The easement curve is also twice as long as a circular curve for the same central angle.

The field work of setting out the easement curve in all ordinary cases may now be summed up in the following very simple rules, which are designed for a length of 200 feet, but by using the expressions in brackets they become of general application:

1. Find the apex and the intersection angle (I) of the tangents and the apex distance (T) in the usual manner. Then $T + 100$ will be the apex distance of the $P\ T\ C$. [$T + 50\ L$.]

2. Set transit at the *P T C* and deflect from the tangent $\frac{1}{2}$ *D*° for the first chord of 100 feet, and $\frac{1}{3}$ *D*° for the second. The latter fixes the *P C C*. [$\frac{1}{2}$ Δ° for $\frac{1}{2}l$, and $\frac{1}{3}$ Δ° for *l*.]

3. Set at the *P C C* back sight to the *P T C*, and deflect $\frac{2}{3}$ *D*°. [$\frac{2}{3}$ Δ°.] This gives the tangent to the central curve.

4. Set out the central circular curve in the usual manner, making its angular length = *I* − 2 *D*. [*I* − 2 Δ°.]

5. At the end of the central curve (the second *P C C*) deflect from the tangent $\frac{3}{2}$ *D*° for the first chord of 100 feet ($\frac{3}{2}$ Δ° for $\frac{1}{2}$) and $\frac{2}{3}$ *D*° for the second ($\frac{2}{3}$ Δ° for *l*). This gives the second *P T C*.

6. Set at the *P T C*, back sight to the *P C C*, and deflect $\frac{1}{3}$ *D*°. [$\frac{1}{3}$ Δ°.] This gives the tangent.

Any intermediate points for grading or for track laying may be set out by the tables or by calculating the deflections.

It may sometimes occur that it is desirable to move the central curve inward a given distance, or, in other words, to assume a value for *s*. It then becomes necessary to determine the other elements of the curve. Transposing equations (25) and (26), we obtain

$$D = 3.708 \sqrt{\frac{s}{D}} \tag{30}$$

$$\Delta = 1.854 \sqrt{s D} \tag{31}$$

We can then use tables III and IV as before.

By means of these formulas a very convenient and valuable application of the easement curve can be made in rectifying a location. When a located line consisting of a series of tangents and circular curves has been laid out over difficult ground, as for instance along a steep hillside, it will often be found upon an inspection of the profile that some portions of the line are satisfactory and should not be disturbed, while other portions can be improved by slight changes, as by moving a tangent or a curve in or out the same distance at each end, or more at one end than at the other, or inward at one end and out at the other. To modify the entire location to fit these changes might be a serious task, and perhaps introduce undesirable changes elsewhere, but where a tangent is moved out or a curve moved in, the connection between the severed portions of the line can be made with great ease and convenience by an ease-

ment curve. To do this find the point where the severed curve and tangent become parallel to each other, and measure the perpendicular distance between them at this point. This distance will be the value of s, which being substituted in equations (30) and (31) gives us $\llcorner$ and $\triangle$, and the point of parallelism on the tangent will correspond to the original $P\ C$, and the curve can then be set out as already directed. If the tangent or curve is to be moved parallel to itself a given distance, this distance will be the value of s. In other cases the point of parallelism can readily be obtained from the field notes of the first location, or by connecting the two lines at any convenient point and measuring the angles, from which the angular distance which the curve must be extended or shortened to bring it to the required parallelism may be readily calculated.

In conclusion the writer would most earnestly urge upon his brother engineers the constant use of easement curves in all cases of curvature exceeding 2°. It is a reproach to the profession that so effectual a remedy for the evils which it is intended to meet has been so long and so generally neglected. The writer must confess that for many years he was equally negligent with his brethren, and for no other reason than that no method of laying out an easement curve had come to his notice which did not appear so complicated and difficult to apply in the field that he was discouraged from attempting to use it. Since he stumbled, as it were, upon the very simple method which is described in this and the preceding paper he has never omitted to apply it, and with the most satisfactory results. His experience on a line of his own construction upon which this method was adopted, over portions of which, almost a continuous succession of 8° and 10° curves, unballasted and but poorly surfaced, he has passed at 30 and 40 miles per hour so smoothly that, but for the elevation of the outer rail it could hardly be noticed that the train was passing onto or off from a curve, as compared with similar experiences on other roads well ballasted, in much better surface and with much lighter curvature, but where no easement curves were in use, where, when traveling at high speeds he has found much difficulty in keeping the coffee from flying out of his cup or himself from flying out of his chair, has convinced him beyond

a question of the great value of the easement curve, and that its general adoption would add greatly to the comfort of the traveling public, and save many a dollar to the treasuries of the railroad companies. It is true that however carefully an easement may be laid out it is liable to become somewhat distorted under the manipulations of the average track man, but the same thing is true of the most carefully laid out circular curve, and yet no respectable engineer would venture to claim that for this reason it is useless to take any care in the laying out of circular curves. And besides this, the track man, however careless, is obliged to keep somewhere near the center of the road bed, and if the easement has been put in before the road bed was graded, as it always should be, he cannot distort it very badly, and with his utmost efforts in this direction the line would still be better than the most perfect circular curve.

The writer does not pretend that these good results can be brought about only by the adoption of the method which he has described, for any other would answer a similar purpose, but he trusts that its extreme simplicity will commend it to engineers who are not expert mathematicians, or who do not feel justified in using the time of a locating party which is costing his employers thirty or forty dollars per day in splitting hairs.

Those who feel sufficient interest in the subject to pursue it further are referred to the writer's former paper in the Michigan Engineers' Annual for 1891, and the articles therein referred to, and especially to a very valuable article in No. 5 of "The Technograph" from the pen of Prof. A. N. Talbot, published since the writer's first paper was presented, in which similar general results are arrived at by an entirely different route, and the subject is treated in a much more thorough and scientific manner than the present writer, with his more moderate mathematical attainments, could attempt, though the great simplification of the formulas and practice which results from the adoption of a uniform length of 200 feet for the easement curve seems to have escaped the professor's notice.

FUNDAMENTAL PRINCIPLES OF THE CONSTRUCTION OF SURVEYING INSTRUMENTS.

L. BECKMANN.

In the construction of surveying instruments we aim to reach the desired result by the simplest way and combine the greatest strength with the least weight.

As a good foundation of a house is a guarantee of its safety and durability, so is the tripod on which we place the instruments a very important feature. As it is the base of the instrument it should be as firm and solid as is consistent with the least weight. The split leg tripod fills these requirements the best, and if we could separate the legs more and make them wider on top, as is done in the large tripods for plane tables, we would have a firmer base yet, but as this would reduce their portability we are restricted to the usual size.

Let us consider the transits first.

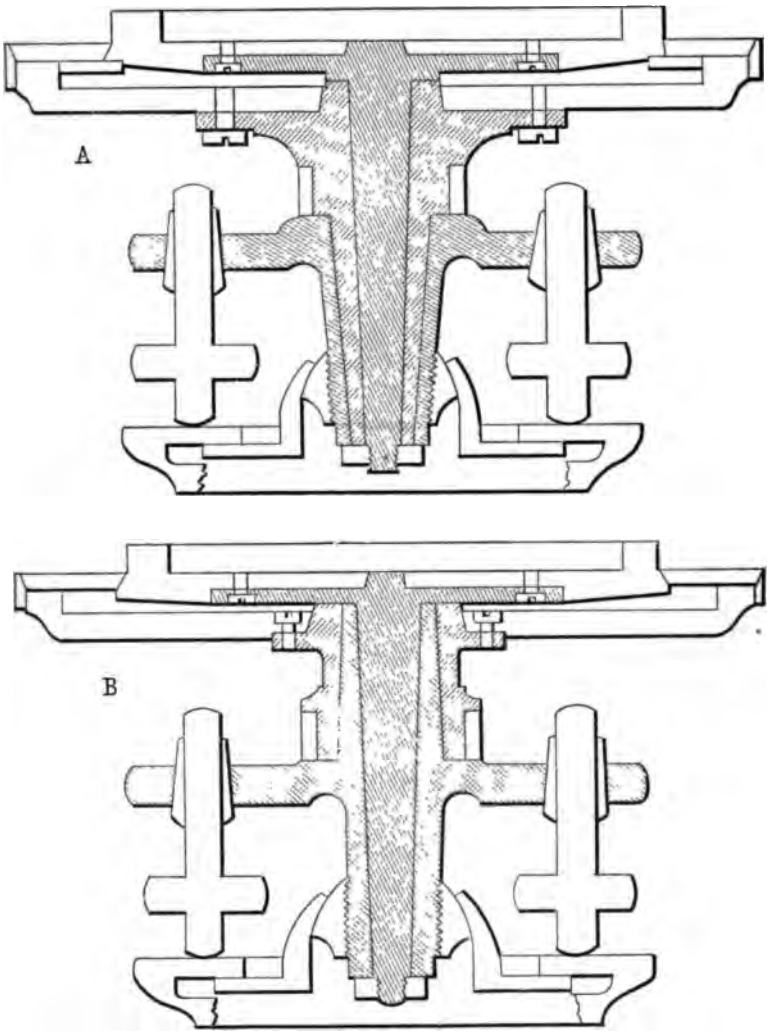
For the purpose of measuring horizontal angles we need an axis provided with means to bring it in a true vertical position. In small field instruments we obtain this vertical position by means of a ball and socket, fastened to the tripod head in a substantial manner, together with two pairs of opposing leveling screws. This ball and socket is now mostly made movable, as shifting tripod head, to bring the center of the instrument over the exact point from which we want to measure an angle.

In Germany and France they do away with the ball and socket, and make the field instruments the same as the larger instruments of the greatest accuracy are made here. The instrument stands direct with three leveling screws on the tripod, held down to the tripod by a hook provided with strong spiral spring. This way all undue strain to the center is avoided. But our American engineer would hardly like such an instrument, as he could not fold the legs together and shoulder the whole instrument, but he would have to take it carefully from the tripod, put it in its box and carry it to the

next point of observation, so this arrangement would not do for light field instruments. We might overcome the strain on the centers by placing them over the leveling head, as is seen yet in some old instruments, but the stability of the instrument is lessened this way to such a degree that we prefer to put the center through the ball and socket and bring it as near to the base as possible.

The center line of the ball and socket should always lie in the same plane with the seats of the leveling screws, so that when two opposite screws are loose, the ball should swing without moving the other two leveling screws from their seat, or these screws will get easily bent.

For the purpose of repeating the reading of angles, the center must be double, one outside carrying the limb circle, the other inner one carrying the vernier. These centers must be absolutely concentric, which concentricity is obtained by turning the centers between two firm points (dead centers) and by good workmanship. The vernier circle should have the same center as the limb circle, and most makers make them that way, both in this country and abroad. A few large firms however have lately adopted a different plan, probably caused by the test of the centers which is to arrest the vernier circle and turn the limb circle underneath. If the levels always remain in adjustment the centers must be concentric to each other. In this new construction the limb center is divided from the vernier center by a solid part of the leveling head so the outer or limb center may be turned without touching the vernier center.



For better illustration I have made two sketches of the different systems. Fig. A is the usual or old way, and Fig. B is the new or improved way.

The improvement is that the vernier plate has a center like a non-repeating instrument and the limb turns on the outside of it so the above level test cannot be made here as the vernier

center does not turn when the limb is turned, but what is gained here is lost in the accuracy of graduation, as they created two different and distinct centers for both limb and vernier. If these instruments are made very good they will stand a test that would seem absurd in the old style of construction. This test is to clamp limb and vernier together and set to zero and read both verniers. Now turn both limb and vernier together without touching upper clamp and tangent screw for 45°, 90°, etc., and see if the zero marks always remain together. But be particular that you change your position towards the instrument every time in taking each reading, that is, if you face N. and S. in the first reading, you have to face N. E. and S. W. in the second, E. and W. in the third, and so on. If the instrument had a little rough usage, or if the centers are worn ever so little, that it would make no conceivable difference in the old construction, the verniers will not read the same although the tangent screw is not touched and even you may find one position, perhaps N. and S., where the limb graduation seems to be perfectly concentric by turning the limb and not changing your position against the instrument. These errors are caused because the limb turns on one center and the vernier turns on another one.

The next important feature in transits is the firmness of all clamps and tangent screws, so the limb will not turn while the vernier is turned. To ascertain this a second telescope is sometimes fastened under the limb circle in large instruments.

For limb as well as vernier a clamp surrounding the center and leaving the limb plate perfectly free with a tangent screw working against a strong spiral spring seems to give the best satisfaction. The rims of the limb and vernier circle are mostly connected with the center parts by ribs running like radii to make them as light and strong as possible. The openings of the verniers should be large to admit plenty of light, and provided with an opaque shade. The graduation should be plain with sharp cut black marks, limb and vernier lying in the same plane and absolutely concentric.

The standards should be firm and strong, equidistant from the center and running parallel with the north and south lines of compass. Whenever no compass is needed it would be best

to cast both standards in one piece as is done in larger instruments for astronomical purposes.

The telescope must be at right angles to its axis, whose bearings must be adjustable to make the telescope swing truly vertical. Also for convenience of reversing, both ends of the telescope should swing over the compass box.

The telescope slide should be a perfect fit and the objective so fastened and truly centered that the line of collimation will not change in any position. If our American engineers could get used to the inverting telescope as our European brothers, we could have a more powerful telescope without increasing the present size. The telescope should give a clearly defined, bright view, with enough magnifying power to see objects 1,000 feet away. The extreme magnifying power is often a drawback, as it darkens the view to such a degree that in dark, misty days nothing can be seen.

As to the leveling instruments, most of what is said about the transits will also have reference to this class of instruments. In the first place, the base or tripod should be rather more firm yet than in transits, owing to the more sensitive level vial used in levels. The center should be strong and of sufficient length to be absolutely firm, it should be as near to the tripod head as possible. The level bar bearing the Ys should be strong and rigid, of hard metal to keep its shape under various conditions. The old way of separating the level bar from the center is objectionable because it increases the distance of the bar from the center; any looseness of center will be more perceptible and it causes frequent adjustment of the Ys. The closer the telescope to the axis and base of the instrument the firmer it will be; therefore, the Ys should be just high enough to let the telescope with level attached pass over the bar. The telescope itself should be evenly balanced on both sides of the Ys, so that if the telescope is focused for medium distance both ends should be equally heavy. The telescope should not be clamped too hard on the Ys, or it will wear the bearings and require frequent adjustment; its objective head should be light to overcome the unevenness of weight if focused for near and far. The rings upon which the telescope revolves should be of the hardest metal and of absolutely equal diameter.

In closing my remarks I will say that in constructing these instruments we have to confront two opposing factors. We want the greatest possible strength and firmness, combined with the least weight and greatest portability. To obtain this result the rule is, make as few parts as possible, a piece that can be cast in one is better than two pieces screwed together; the simpler the instrument, the fewer the adjustments, the better for the instrument.

PRESIDENT: Of course I cannot say that all the members are as much interested in this paper as I am. It interests me a great deal. There was one point he did not touch upon, which I have been hammering upon a good many years: The length of the transit axis.

Now suppose there is a little deviation in the position of the transit axis. If it is a short one, by so much is the line of sight the more readily turned out of place, so much more error there will be to the adjustment of the line of sight or the ranging of a straight line.

I see no reason why the limit of the length of the transit axis is not the outside diameter of the plate and I would like to have it made that long. I am also in favor of the three Ys.

Another thing I wish to emphasize, that I don't think Mr. Beckmann has put any too strongly, is the use of the inverting telescope. If we start the objective slide a little, we will have here a focus of seven inches. One may be ranging a line half a mile. You have got hold of seven inches of it. With an inverting telescope there will be no difficulty in placing the cross wires nearer the eye end of the telescope and getting a ten inch grip. That is one use of an inverting telescope. Put the cross wire ring back there; three-fourths of an inch is enough for the eye piece. I have such a telescope and if I break a cross wire all I do is to take out these two screws and put the cross hairs into my instrument without taking the ring out. I haven't got to fuss around again to put those cross wires in. I didn't take them out. But as we were to have this paper on elements of precision, perhaps that is a little out of order.

COL. MUENSCHER: You want the ring put close to the eye

end. One thing I would like to modify a little. The slow motion of the body of the instrument—the recognized use of the spring. The spring ought to be very strong, or there will be constant motion of the instrument. I have an old instrument and three or four years ago I had occasion to have it repaired, and sent it to Aloe at St. Louis, and he took out one of the pairs of screws and put in a spring, and I never have had any peace with that instrument since. The spring wasn't strong enough.

PRESIDENT: Mr. Beckmann will be glad to fix it for you, no doubt.

MR. STEELE: I feel that we are under obligations to the manufacturers of these fine instruments for coming here and representing their own work, and for sending work here for us to examine, and whatever we may say in regard to them, is done in a spirit of pleasant criticism, for their good, and for our own as well. I think that one of the important things that we have aimed at has been overdone. A light instrument has been attempted, and lightness in all its parts has for some years now been the aim of the manufacturer, and to some extent that has been carried too far. I think I am as lazy a man as any here, and would like to do as little work and get as big pay for it as I could at the same time, but I don't want to do the work over again. When it is once done, I want it done. Now I will call no names, but here is an instrument that you can judge from its general appearance is a fine one. It stands upon a tripod which has been attempted in the line of lightness, and as the maker supposed undoubtedly, strength also, but I consider it faulty, very much so. These pieces are all ash and are dug out on the inside, as you will see here, so that only the shell is left, not as thick as that pencil. These two ribs here are also carved out in various places to reduce their weight. The nuts that go upon these bolts are all loose. They are liable to come off whenever you are least expecting. That should be prevented, and it is done in this other instrument—the only one I have ever seen.

Now, it stands very much to reason that if we have a heavy instrument as this is, upon a light tripod, any strain will affect the instrument much more than as though we reverse those

conditions. This instrument will shake because there is not as much under it as there should be. Neither is the tripod strong enough to stand the rough usage of the field.

I have tried several instruments, and I have a small one now on a good solid tripod, and last summer it was used by a railroad engineer for a short time, and stood upon a sandy bank where the sun was pouring upon the bank and reflected upon the instrument, and staid there for two hours, and during all that use the very last sight, in coming back and testing each one, came on to the nail where it was first set off. In other words, the effect of the intense heat on that instrument had not changed anything at all. The engineer remarked that he could not do that with any instrument he had ever seen before. It occurred to me that the very fact that it was a light instrument was one reason it was not affected, less liable to be affected by the heat.

This instrument, however, will illustrate also what Mr. Beckmann has told you. You may take your magnifying glass and set at zero and turn it around, and you will find the other side is just one graduation off. You may try it a dozen times and find it so every time. That is a perfect illustration of what Mr. Beckmann has been showing us.

COL. MUENSCHER: That instrument seems to have the same defect Prof. Davis speaks of, having a very short axis. I suppose the shape the standard is put in is with the idea of making the standards steadier, but it seems to me it does not accomplish the object.

NOTES IN A ROLLING-MILL.

E. H. MUMFORD.

There is relatively little understood regarding the momentary work required to roll sheets and bars in the rolling-mill of today. I mean that, while experience has taught engineers the advisable amount of power to supply and the marginal excess of fly-wheel inertia, yet the actual work done on a given pass and the proportion in which this work is shared between

applied work on the material and neck friction of the rolls is still, so far as I know, a matter of conjecture.

The random notes I have been able to record here have been taken in a copper and brass mill, and I have thought it worth while to take a case in point in which the fracture of a "wabble connection" at an instant during the passage of a certain sheet of copper furnished data from which to estimate the conditions incident to doing a certain amount of work of this kind. The conditions were as follows: A sheet of copper eight feet wide and seven-eighths of an inch thick was being passed for the first time between rolls thirty-two inches in diameter and one hundred and twenty inches long. It had entered about eighteen inches when the connection above mentioned failed by twisting. The reduction in thickness averaged one-thirty-second of an inch. This and the compressive resistance of the sheet are doubtful data of the work, as the reduction was not exactly uniform the whole width of the sheet, and the temperature was only to be estimated by the appearance of the sheet, which was, apparently, at about the temperature, or degree of incandescence, at which a smith would work tool steel in the fire.

The conditions of the work being as above, a wabble of the section shown in the attached drawing was twisted short off at the face of a bolted flange from which it projected, no bending stress entering into the problem, and the plane of the fracture being, as nearly as possible, at right angles to the axis and presenting very uniform features on the face of the break. In calculating the strength of the twisted section I have used the usual formula:

$$M = \tfrac{1}{2}\, q_s r^3 \qquad (1)$$

for the included circular portion, in which M represents the moment of torsion, q_s, the shearing resistance of the cast iron, and r, the radius of the circle included. For the parts of the section without this circular section, I have taken them as cut up into strips one-eighth of an inch wide and calculated their moments separately, using the formula:

$$\Sigma M = \Sigma q_s a r \qquad (2)$$

in which a is the collective area of the four small strips of a common mean radius, r. The value of q_s, for this particular

case, I have determined by taking a test piece from the casting which failed and testing for tensile strength, f, in an Olsen machine. The result of four tests gave me average f equals 12800 pounds per square inch. The deduced value of q is

$$q = \tfrac{3000}{1250} f = \tfrac{3000}{1250} \times 12800 = 23680 \text{ pounds per square inch.}$$

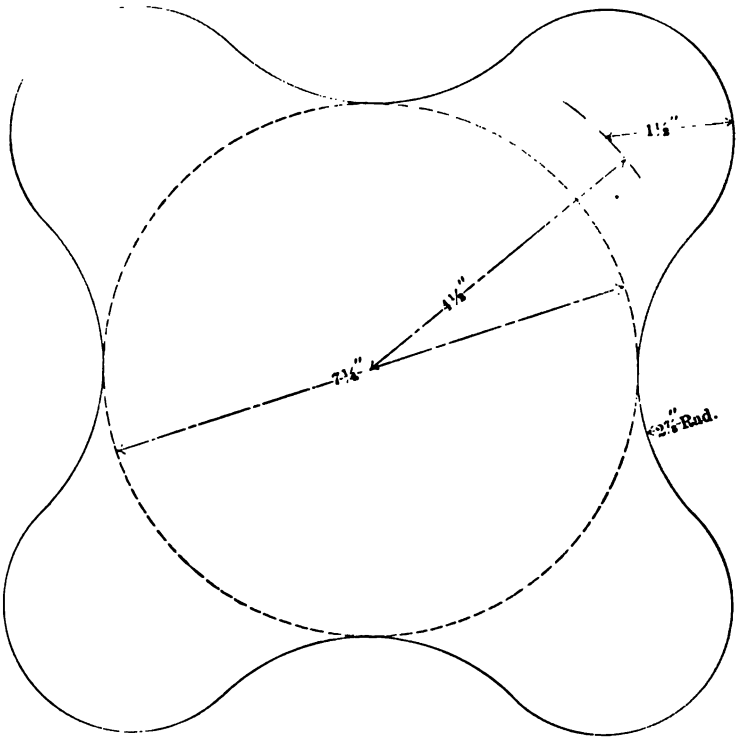
Substituting this value in (1) and (2), I have for (1):

$$M = 127701$$

and for (2):

$$M = 331900$$

giving a total of 459601 foot pounds of moment. I would explain the low value of f as partly due to the fact that the



test piece was taken from the body of a large casting and was, consequently, very "open" in its structure, but I deem it a fair average of the fractured section.

The velocity of rotation is 36 *R P M* for the 32-inch rolls;

therefore the speed with which the sheet passes is $\frac{32}{12}\pi \times 36 =$ 302 feet per minute, assuming that the surfaces of the reduced sheet do not slide on the rolls. This implies that the thicker entering sheet is, as it were, held or pushed back, while its central portion is squeezed ahead at the velocity of the surface of the rolls. I have here a piece of brass wire, one-quarter of an inch wide and one-eighth of an inch thick originally, on which a pair of twenty-inch rolls have been allowed to stop in the process of reduction. The fibres of the wire, such as they are, have been etched into prominence by dilute nitric acid and have an interest in this connection. The curious darker portion is found at two places on the section, namely: at the point where the rolls ceased to act, and at the end where the shear cut it off, forcing the fibres to one side. As the dark appearance vanishes at a certain angle of reflected light, it may be supposed that there has been a new fibrous structure created by the action of the rolls, due, I would infer, to a longitudinal movement of the particles past one another. Any such action will take more prominence in a sheet in which the extension is almost entirely lengthwise, or in the direction of the pass.

Taking the crushing strength of cold cast copper at 100,000 pounds per square inch, and assuming that its malleability is rendered double by its temperature, and assuming 1-32 of an inch reduction, the vertical projection of contact with the rolls is approximately a strip 0.71 inches wide and 96 inches long, which gives as area in contact (that is in projection) and in vertical crush, 68.16 square inches and a total pressure of 3,408,000 pounds.

The reflections we are now led to are as follows:

We have a vertical pressure of 3,408,000 pounds acting equally on each of two 32 inch rolls at an arm of 0.355 inches to resist their turning. Expressed in foot pound moments this is

$$\frac{2}{12} \cdot 0.355 \cdot \frac{3408000}{2} = 201{,}640 \text{ foot pounds.}$$

leaving as a balance from the moment represented by the breaking of the wabble

$$459{,}601 - 201{,}640 = 257{,}961 \text{ ft. lbs.}$$

This must be sought in neck friction.

An expression for this is

$$M = 2\,f\,p\,r$$

in which f is the coefficient of friction, p the total load on one roll, and r the radius of the necks. That is

$$M = 2 \cdot \frac{10}{12} \times 3{,}408{,}000$$

for necks, 20 inches in diameter.

$$i.\,e.\quad 257{,}961 = 5{,}680{,}000\,f$$
$$f = \frac{257{,}961}{5{,}680{,}000} = 0.045 \text{ plus.}$$

We may expect to find an excessive load on the roll necks.

The weight of these rolls is, of course, very considerable, but may be neglected in comparison with the other load on the necks. Disregarding this, then, in the case of the bottom roll (the top roll is counterbalanced, but the rider brasses which support this roll add their frictional moment to the whole) the pressure per square inch of projected area is

$$\frac{3408000}{2 \cdot 13 \cdot 16} = 8192 \text{ lbs. per square inch.}$$

This is an abnormally great pressure, and we might expect a much higher coefficient of friction. We note, however, that the speed is very slow and that a sheet ten feet long would pass in two seconds, and then an ample interval for cooling and relubrication of the necks follows. In this nearly instantaneous action, it is not to be supposed that actual cutting would occur unless the elastic limit of the materials were exceeded. The lubricant used is, as might be supposed, the very thing for such exigencies, partaking, as it does, as much of the nature of Stockholm Tar as of oil. A heavy, pasty mass of it is packed all about the necks of the rolls and my experience with it would lead me to expect that the roll necks would rather behave themselves and keep cool than be treated to an additional dose.

This pressure, enormous as it is, amounting to 1700 tons and more, the weight of a good sized ship, is amply provided for in the massive housings which contain these rolls. These are of cast iron and have a section on either side of the neck of 264 square inches, a total section of four times 264 equals 1056 square inches. In my observation, these housings fail oftenest, owing, apparently, to a very slight change of form in the top or bottom portions joining the sides. It may occur to some of

my hearers that a rather extensive energy factory must be at the other end of the twisted wabble connection from the rolls; yet the engine is only 28x36 inches, taking 80-pound steam through a throttling governor, which wire-draws it down to a mean-effective of about thirty-five pounds on an average, and has other work to do on the other side of the shop, and a little hitching-strap in the shape of a twenty-inch belt to keep it from getting too light hearted. The influences that twisted this wabble are largely the inertiæ of various rotating pieces of mechanism enumerated as follows:

One 15-ft. fly wheel	80 *R P M*	energy equals	1174347	ft.	pounds.
One 14-ft. gear	36 *R P M*	" "	177792	"	"
One 6¼-ft. pinion	80 *R P M*	" "	89085	"	"
These rolls themselves		" "	10739	"	"
Connections driving rolls		" "	4514	"	"
Roll train on other side of engine		" "	2850	"	"
A grand total of.....			1459327	"	"

You will see in all this a tendency to keep things moving. In fact, give these reinforcements a chance to get into line of battle with that sheet, and, rather than give it up in two seconds, they would exert the power of more than thirteen hundred horses.

I may add that the wabble which failed is generally, as in this case, designed to be the weakest part of the mechanism, as it is expeoted that conditions will arise rendering it obligatory that something shall yield gracefully to the fabled resistless force and immovable obstacle.

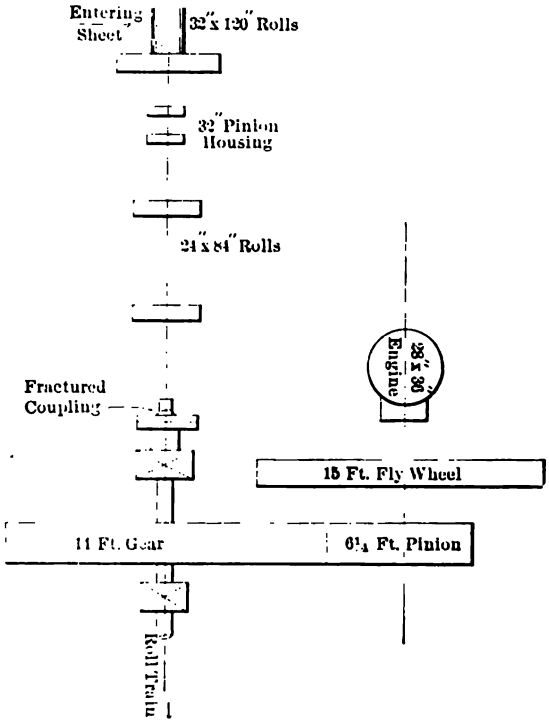
To more clearly explain the location of the part that failed, I append the attached diagram of the plan of the mill, as drawn on the blackboard at the time the paper was read.

I have a section of the casting with which I made the test, and a microscope and section of wire, that may be of interest. This wire was planed in two and the surface polished and the fibre is almost entirely at the middle of the wire.

There are curious things in connection with this process. The copper is always rolled while hot, and brass is never rolled hot. There is only one composition of brass that is rolled hot, and I think it is not generally known what it is.

PRESIDENT: Outside of the questions raised here, which are of interest to men engaged in mechanical pursuits exclu-

sively, of course there is a great deal brought forward of interest to us all in the matter of strength and resistance of materials, and it is possible the specimen there under the microscope would furnish some ideas with regard to the changes that take place in passing materials through the rollers and possibly raise some suggestions as to the injury or



benefit which metals receive from being treated in the rolling mill.

I am very sorry that we are not able to have the light of Prof. Cooley's countenance on this subject, for I think he would be glad to be here himself as well as for our benefit.

A paper of this character requires closest study, and office study, rather than study here, and it of course will appear in the proceedings, and gentlemen who wish to present anything further upon the same subject, will then have an opportunity of doing so.

THE ARCH: ITS ACTION.

CHAS. E. GREENE.

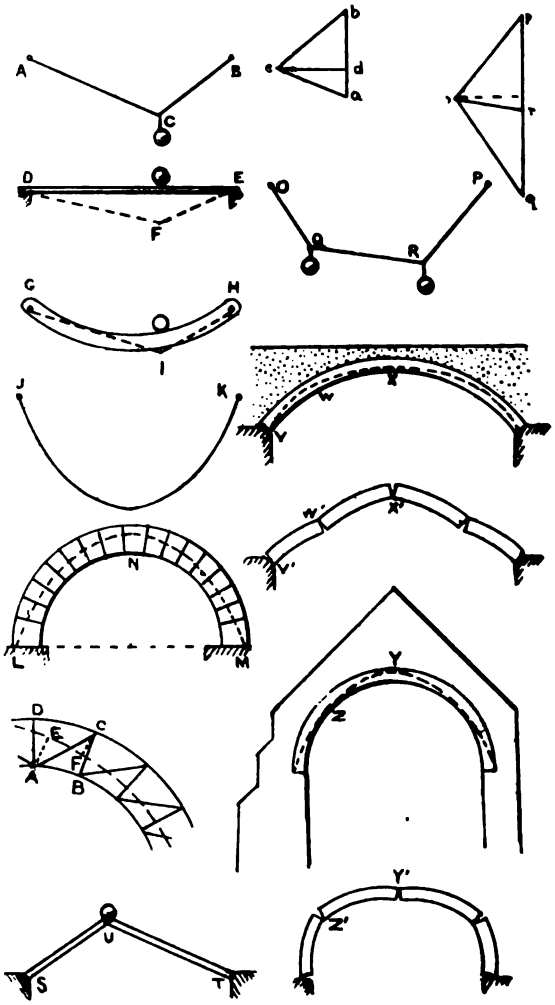
Since the arch in wood, in iron or in stone, is frequently used in construction, and since its analysis, as found in many books, is not very simple, the writer offers here a brief explanation of the action of an arch under a load, in the hope that the reader may get a clearer view of the matter, even if he may not be justified in attempting at once to calculate the strength and stability of such a structure.

By means of an arch an opening is spanned between two fixed points or abutments which keep the arch from spreading, and against which it therefore exerts a horizontal thrust. It may have a variety of outlines; in masonry the arc of a circle is most frequently employed. The centre line, midway between the exterior and the interior bounding curves, is usually assumed as the theoretical or skeleton arch.

Suppose that to two fixed points, A and B, in a horizontal line which represents the span, a string is attached and a weight suspended from the same at C, as in the first sketch. The string forms what is called an *equilibrium polygon*, which, in general, is the broken line assumed by a cord carrying one or more weights at different points, and hanging freely from two fixed points. See also O Q R P. If the weight is distributed continuously the polygon becomes a curve, as, for example, J K, which represents a hanging chain.

As is known to many, if a vertical line b a is drawn to a scale to represent the weight at C in pounds, and c a and c b, parallel to C A and C B, are drawn from the extremities of the vertical line until they meet, these lines will, by the same scale, give the tension in pounds in the respective parts of the string to which they are parallel. The horizontal line c d will be the measure of the force with which the two fixed points A and B are drawn towards one another.

If, in place of the string, a bar or rod D E is put upon the


A
B
C
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two fixed points with the weight in the same position as before, the bar will have a tendency to assume the form *D F E* of the same equilibrium polygon. Its stiffness resists that tendency, and the vertical distance of each point of the bar above *D F E* is proportional to the bending moment at that point. Hence the greatest bending moment and the weakest point of a uniform bar is at the weight.

Again, if a curved bar *G H*, carrying the same weight, is substituted for the straight bar, this curve has the same tendency to assume the form *G I H*; one part tends to move down or out, and another part tends to move up or in; and here again, the vertical distance from the centre line of the bar to the lines representing the equilibrium polygon is proportional to the bending moment at each point.

Bend a moderately stiff wire into the arc of a circle, drill a hole through each end, as at *G* and *H*, by which to suspend it, and attach a sufficient weight at any point of the wire, so that the weight of the wire itself may be insignificant. When the strings are brought into such a position that a line joining the two holes is horizontal, and the distance between the two holes is the same as before the wire was hung up, these strings indicate the lines of action of the abutment forces and intersect upon the vertical line through the point of attachment of the weight. Imagine the apparatus inverted and we have the abutment thrusts, which have equal horizontal components, known as the horizontal thrust of the arch. In the triangle of forces, such as *a b c*, *b a* represents the weight by a scale of pounds to the inch, *c a* and *b c* the two abutment reactions, *c d* the horizontal thrust, and the bending moment in foot pounds at any point of the arch is equal to the vertical ordinate in feet from the centre line of the rib to the equilibrium polygon multiplied by the horizontal thrust in pounds.

The tendency thus far has been for the structure to move towards the equilibrium polygon. Suppose the polygon *A C B* to be inverted; two bars *S U T* must now be used. The force in each bar will plainly be thrust, given by a figure like *c b a*, and *c d* will be the horizontal thrust against the abutments. A straight bar on *S T* would tend to move away from this

polygon, as would also the curved bar *G H*, if erect like an arch. Turn the figure *G I H* upside down, and notice that the arch tends to move away from the equilibrium polygon at all points. Erect a bent wire so as to form an arch between two notches on a board or table, press the finger on the summit of the curve, and this action can be plainly seen.

The distances vertically from the equilibrium polygon to the centre line of the arched rib are still proportional to the bending moments, and the right equilibrium polygon, out of all those which might be drawn to intersect on the vertical line through the weight, is the one which has the value of *c d* in pounds the same as the horizontal thrust the arch would exert against its abutments when carrying the given weight *b a*. How to determine this thrust in a given case is beyond the limits of this article.

The weight of an arched ring of masonry of uniform thickness *L N M*, is distributed so nearly like that of the uniform chain *J K*, that the dotted equilibrium curve of *L N M* closely resembles *J K*. This arch therefore has its weakest points where the dotted curve deviates most from the centres of the joints, and, if the stones are so narrow that sensible movement occurs, the arch ring will descend at *N*, move outward at the haunches, and begin to revolve outwards at *L* and *M*. If the load were distributed uniformly per horizontal foot, the equilibrium curve would be a parabola, as in a suspension bridge cable, and such a curve inverted gives the best form of arch to carry such a load.

If a masonry arch, such as *V X*, is filled above with loose material to the horizontal line, the curve of equilibrium will resemble the one sketched in a dotted line. As the load is comparatively light at the crown, the haunch near *W* will tend to crowd in and the crown *X* will be forced up. At both points the movement is away from the equilibrium curve, and the failure will be like *V' W' X'*. By making the arch ring broad enough to keep the equilibrium curve well within it, stability is assured.

In the example below the last, the load is excessive at the crown, *Z* and *V* are the critical points, as shown by the dotted

line, and the arch ring, if too narrow, will fail like Z^1 Y^1, coming down at the crown, even if the abutment is strengthened against yielding by buttresses, as on the left side.

If a metal rib like a truss is employed, the equilibrium curve is still useful. If A B C D is one panel of such a rib, and E F the equilibrium curve for a certain loading, the thrust in the piece D C will equal the thrust in the equilibrium curve at E multiplied by $\frac{A}{A}\frac{E}{D}$ while the thrust in A B will equal that at F multiplied by the ratio $\frac{C}{C}\frac{F}{B}$, the dotted lines to E and F being perpendiculars to the curve.

It is not difficult then, if one has a general idea of the location of the equilibrium curve, to determine the weak points in the arch, and to decide at what places the load may with advantage be increased or diminished. It is evident also that the addition of a moving load at X will improve the stability of that road arch, and that an increase of load in the road above W will decrease its stability. If the effects of the steady and moving loads at any point are of the same kind they are added, if of opposite kinds the difference is taken.

Some of the principal points have now been briefly sketched, in order to show why one arch will stand and why another will not. The abutments are supposed to be immovable; if they yield under the horizontal thrust, the arch is endangered, independently of other considerations.

The writer has applied this method of treatment in detail in that volume of his "Graphics" which discusses the arch.

THE DISPOSAL OF SEWAGE ON LAND,

With Particular Reference to Inland Villages and Isolated Buildings where Public Sewers are not Accessible.

GEO. S. PIERSON, M. AM. SOC. C. E., KALAMAZOO, MICH.

Our knowledge of the causes which influence the purification of sewage when applied to the soil has increased markedly during the past few years. It is still an open question, however, whether water which has been contaminated with sewage can be so thoroughly purified as to be entirely safe for culinary uses.

It is a matter of common knowledge that the purest of natural waters, so far as organic matter is concerned, are those which have undergone prolonged filtration through the soil. And it is well established that the purification of sewage by intermittent application to the soil is the most complete, and where the conditions are favorable, much the most desirable. In fact, it is not unusual to supplement chemical processes by subsequent filtration through the soil whereby the purification is carried to a higher degree.

The dangerous impurities with which sewage is charged consist mainly of different organic compounds in various stages of decomposition. It is not practicable, or in fact desirable, to prevent the decomposition of these organic compounds. With the exception of the small portion which may be consumed as food by animal life, they must be resolved into their elementary substances before they can again be utilized by plant life or otherwise rendered innocuous. It is practicable, however, to so control the conditions of decomposition that it shall not be offensive, and the resulting compounds shall be fixed and rendered harmless by some surrounding medium. The soil is a medium which not only renders these products innocuous but also favors a mechanical separation and aeration very conducive to the rapid disintegration of the putrescible matters contained in the sewage, and, where utilization is desirable, to their absorption as well.

In the report of the select committee on the Metropolis Sewage it is stated that:

"No efficient artificial method has been discovered to purify, for drinking and culinary purposes, water which has once been infected by town sewage. By no known mechanical or chemical means can such water be more than partially cleansed; it is always liable to putrefy again. Processes of filtering and deodorization cannot, therefore, be relied upon to do more than mitigate the evil. Water which appears perfectly pure to the eye is sufficient, under certain conditions, to breed serious epidemics in the population which drinks it. Soils, however, and the roots of growing plants have a great and rapid power of abstracting impurities from sewage water and rendering it again innocuous and free from contamination."

The process of purification of sewage by filtration through the soil is similar to that of burning up or oxidizing the organic matter leaving only a harmless mineral residue, which is soluble and passes off in the effluent, leaving the filtering medium, when properly managed, undiminished in efficiency. The application of sewage intermittently serves to increase the amount of oxidation similarly to opening the draft of a furnace.

The changes produced by wet oxidation, however, are not the same as those produced by heat, there being intermediate processes. In the former the nitrogen of the organic matter first combines with the hydrogen to produce ammonia which, upon uniting with oxygen, produces nitric acid. This, in turn, combines with potash, soda, lime or some other base present in the sewage or in the soil to produce a soluble nitrate. The extent to which this sequence of combinations has proceeded is a measure of the degree of purification of the sewage. The larger the amount of nitrates in the effluent, therefore, and the smaller the amount of ammonia, the more completely has the organic matter of the sewage been destroyed. Later investigations have shown that the earlier of these processes depend on the presence of living organisms.

This has been clearly established by exposing solutions of organic matter, in which the living organisms have been destroyed, freely to air filtered through cotton wool. Under these conditions no nitrification took place. Upon the introduction of a small quantity of soil or other medium containing these living organisms, however, they rapidly multiply and the purification proceeds.

It was formerly supposed that the oxidizing power of a soil depended solely on its porosity, being due to its contained oxygen. Later investigations have shown that a porous medium is not essential and that sewage may, indeed, be nitrified in a glass bottle or when passing over polished pebbles. Although it is proven that porosity is not essential it favors the rapidity of the nitrification in the soil by presenting an immense surface covered with oxidizing organisms and generally well supplied with air requisite for the continued discharge of their functions. In order to more fully illustrate this point the author made the following experiment:

Fifty cubic centimeters of ordinary screened mason's sand, of a fineness of 40 grains per lineal inch, were placed in a chemist's burette, having first been thoroughly freed from moisture by continued drying at a temperature of about 225°. Water was then introduced into the burette from below by aspiration, so as to facilitate the expulsion of contained air until the voids were entirely filled and the amount of water introduced carefully noted. The burette was then opened below and the excess of water over that naturally adhering to the particles of sand was allowed to drain off. From the facts noted the following computations were made:

The total air space in the dry soil was 36 per cent of the cubic contents. The water adhering to the particles of soil was 18 per cent of the cubic contents. The total superficial area of the particles of soil for each cubic foot was 2,270 square feet. The water adhering to the particles of soil for each foot in depth was equivalent to a film of water 1-1000 inches thick and 2,200 square feet in area. Since the purifying agencies within the soil and its contained air have been proved to be active to a depth of at least three feet we may assume that the surface of sewage which is exposed to the action of these purifying agencies is approximately 6,600 times greater when sewage is applied to the soil intermittently than when it is simply impounded over the same area.

The part which these organisms (bacteria) play in the destruction, or rather in the transformation, of the organic impurities of the sewage is stated so clearly and pertinently by T. Mitchell Prudden, M. D., in his book on "Drinking Water and Ice Supplies," that I quote his words as follows:

It has been found that if one starts with an artificial filter bed of perfectly clean sand, containing no bacteria, and floods it with dirty water the water which comes through for the first few days, and for a much longer time if the weather be cold, will be but little, if at all, purified. Its coarser suspended particles may have been caught in the sand pores, and so it may be clearer, but its dissolved organic matter and its bacteria may not be at all diminished. Indeed for some time, strange

as it may appear, the number of the bacteria may have largely increased. In fact, it appears that the pores of such a fresh sand-filter with the organic matter suspended in the water, form a most excellent breeding place for bacteria.

This seems discouraging, but let the experiment go on, and after a while if the dirty water has not been forced through the sand too fast, it will be found that the number of living germs which come out in the water at the bottom is growing steadily smaller and finally the water may be nearly or quite germ free. Now, if the chemist exposes some of the filtered water to his delicate tests he may find that the organic matter which was in solution in the water at the top has already diminished or entirely disappeared, being represented, perhaps, by nitrogen, which has formed harmless combinations with oxygen.

It really seems as if the more of the living, growing bacteria you had in the upper layers of your filter bed, the freer became the water below both in bacteria and organic matter. This is, in fact, the case. We do in this experiment what nature does on a larger scale- make the bacteria fight the organic matter and themselves.

But how is this effect produced? The bacteria are so small that hundreds of them could easily pass abreast through the smallest spaces between the sand particles. What holds them back?

When the sand particles at the upper portion of these filter beds have been carefully examined it has been found that they are, after a few days, completely encased in a slimy gelatine-like envelope, formed of a material which many bacteria secrete around themselves as they grow. This bacteria-formed slime more or less fills the pores of the filter bed, enclosing the bacteria themselves and the sand particles, and catches and holds fast on its sticky surfaces not only suspended matter of various kinds but the new bacteria which come onto the filter and start to work their way down through its pores. Here, many of them, like good prisoners, set to work to make the best of the situation, and if their nature permits, turn to and help to make more of this trap-slime to capture the next comers.

Many of the enlarged germs, however, do not form this material and these may die in large numbers where they lie. On the other hand, this enforced detention is simply paradise for many of the germs. Here they are resting at ease in a slimy confinement, with boundless supplies of just the food they want slowly trickling by them. The food is dead organic matter, which the average bacterium simply dotes on and recks little whether it be in solid form or in solution, so there be enough of it. At it he goes then, and by some wholly inscrutable phase of the life power in his tiny body, asunder fall the atoms which have once been parts of animal or plant. That part which the tiny life spark needs to keep its glow agoing is appropriated. The rest he leaves, its atomic cravings unsatisfied, and only too ready to succumb to the wiles of the ever amorous oxygen, which must always be present in a perfectly acting filter bed.

The slowness and the intermittent character of natural soil filtration is a very important matter in the accomplishment of perfect results, because in the times between rains the soil pores have a chance to become filled with stores of oxygen in the form of ground air.

Behold now the secret of this marvelous alembic into which may go things most foul and harmful, but out of which comes the very type of cleanliness—clear spring water. It is largely the bacteria, living, growing, multiplying, following their life impulses silently and unseen, each after its kind, which, supported by the active agency of the oxygen, bring about this beneficent result.—*Prudden, in Drinking Water and Ice Supplies.*

A test made in one of the experimental filtration tanks of the Massachusetts State Board of Health to determine the distribution of bacteria at different depths gave the following results:

Number of bacteria found in one gramme of sand at various depths.

Distance from Surface.	May 22, 1889.	Distance from Surface.	May 22, 1889.
0 to ½ inch	1,700,000	5 inches	63,400
½ to ¾ "	105,000	8 "	30,700
1¼ to 1½ "	207,200	12 "	34,100
2 inches	60,200	19 "	12,300
3 "	111,300	60 "	4,100

The most rapid decrease is in the upper few inches.

Koch says that the micro organisms in the soils he has examined diminish rapidly with the depth and at the depth of a metre the soil is nearly free from bacteria.

The experiments of Lawes and Gilbert indicate that the action of these organisms is very uncertain below a depth of 12 or 15 inches.

When abandoned privy vaults or other deposits of organic matter are laid bare by excavating it will be observed that in the upper portion, immediately beneath the surface, the organic matter has disappeared and that as the depth increases the purification has been less and less until at the depth of several feet it will be found that it has proceeded but slightly even after several years. In fact, abandoned privy vaults are often found in streets which have been used as public thorough-

fares for more than a generation, the lower portions of which show no sensible purification of the organic matter.

It is therefore apparent that there is a radical difference between the processes which ensue in the ordinary cess pool or privy vault and those which follow upon the application of sewage to land under proper direction and by the methods dictated by recent knowledge.

Many interesting facts have been brought out by the experiments of the Massachusetts state board of health during the last two or three years. They can scarcely be touched upon in the limits of a paper of this kind, but I present the following table as summarizing some of the results obtained by various soils for periods of three to eight months, mostly in the second year of filtration.

Character of Soil.	Gallons of sewage per acre per day.	Percentage the sum of ammonias of effluent was of the sum of ammonias of the sewage.	Percentage the number of bacteria in the effluent was of the number in the sewage.
Coarse mortar sand	117,000	1.4	3.
" " "	60,000	0.4	0.02
" " "	55,400	2.5	0.19
Coarse and fine sand and fine gravel	42,600	0.5	0.08
Fine white sand	28,700	0.4	0.003
River silt, mostly fine sand	13,400	0.6	0.002
Three feet eight inches sand and gravel Ten inches yellow sandy loam Six inches brown soil	8,880	0.4	0.001

The several amounts per acre of sewage set opposite the different soils are the amounts they were found by experiment to be capable of purifying indefinitely.

The table exhibits in a general way the superiority of the more open soils as to purifying large quantities of sewage and of the compact and more finely divided soils in removing living organisms.

In the experiments above recorded sewage was applied

intermittently. In intermittent filtration the nitrification was active and, as shown by the ammonias, 99 per cent of the organic impurities were removed, while in continuous filtration the nitrification ceased, and the same sand filtering the same quantity of sewage, stored impurities for a time, but finally poured out an effluent quite as impure as the applied sewage.

This shows distinctly the radical difference in result between intermittent and continuous filtration, due undoubtedly to a lack of oxygen.

It is proven that these processes of purification may proceed in this latitude in winter. The experiments at Lawrence, Massachusetts, have shown that the nitrification was about nine-tenths as complete in winter as the mean for the year.

It should be stated in this connection that nitrates which are the product of the nitrification or oxidation of the organic matter contained in sewage, supply nitrogen in its most available form as plant food. In the absence of plant life the excess of these nitrates, being very soluble, passes away with the effluent in a harmless form making the soil self-renewing in its capacity for sewage purification. Instances are on record where sewage has been applied to the same area for more than a century and the soil still effectively purifies it.

The following practical conclusions may be drawn from the facts above cited:

1. The sewage should be applied at or near the surface of the ground in order that the bacterial action may be complete.

2. The soil should be thoroughly aerated so that the oxidation may be as thorough and rapid as possible.

The second of these considerations demands that the soil in order to purify considerable quantities of sewage shall be porous and reasonably free from finely divided particles having a tendency to form, with the sewage, a surface coating which may exclude the air; and also that the sewage be applied intermittently so that the air, following the lowering stratum of sewage, may be drawn into the pores of the soil and intermingled with the sewage.

Sewage may be applied by the following methods:

1. Broad irrigation.

2. Intermittent filtration over limited areas.

3. Sub surface irrigation at the depth of a few inches below the surface.

Broad irrigation is available when large areas of land can be obtained somewhat removed from compactly built neighborhoods and where the utilization of the sewage is desired.

The amount of land necessary for this method of disposal varies according to circumstances but for ordinary conditions may be said to be about one acre for each 100 persons.

Intermittent filtration is available where the amount of land that can reasonably be secured is limited. On properly prepared areas of porous soil one acre of ground will be sufficient to purify about 100,000 gallons of sewage daily, indefinitely, or for about 1,000 persons at the usual rate of sewage per capita in the United States.

Sub surface irrigation is applicable to isolated houses, public institutions and to small villages where a suitable soil can be obtained. It has advantages over any of the other methods in that it can be employed nicely on a small scale to meet the wants of a household of a few members, or on a larger scale to meet the wants of a larger number, without complications arising from a necessary association of interests. It requires less attention than the other methods and there is nothing unsightly about it.

In the current number of the Engineering Magazine (January, 1892) Geo. W. Rafter, C. E., in an article on "Sewage Disposal" gives the following résumé of the question of sewage disposal as it stands today:

1. By reason of the lack of cheap labor, broad irrigation will not, generally speaking, be adopted in this country.

2. Intermittent filtration is the preferable method where a high degree of purity is required and the conditions admit of its use.

3. Chemical treatment may be used where the object is to merely purify the sewage enough to admit its discharge into a stream or other body of water without creating a nuisance.

4. Chemical treatment alone should never be used where the effluent goes into a stream, pond or lake used as a public water supply at any point within the influence of the sewage.

5. Combination treatment by chemicals and intermittent

filtration may be used when a high degree of purity of effluent is required, but at greater cost usually than by intermittent filtration alone.

To decide just which method to use in any given case will require the best judgment of a skillful sanitary specialist.

Mr. Rafter also remarks that within the next few years we may expect to see a great extension of sewage disposal works in all parts of the country.

In March, 1891, the writer made an examination of the sewage filtration beds at Pullman. The soil of the filter beds is the rich alluvial prairie soil underlaid by a yellowish clay subsoil and poorly adapted for purifying large quantities of sewage, especially when the temperature is low. Nevertheless, the results obtained here are very flattering.

A sample of the crude sewage was taken at the end of the carrier for analysis, and also a sample of the purified effluent was taken from the man-hole to which the tile drains converge. The effluent was clear and sparkling and not unpleasant to the taste. The table below contains the results of an analysis of the samples collected as above stated.

Analysis of crude and purified sewage from the Pullman sewage farm (Parts per 100,000.)

	Crude sewage.	Purified sewage.
Temperature	51 F	38° F.
Albuminoid ammonia	.60	.040
Free ammonia	.30	.037
Nitrogen as nitrates	.41	.180
Oxygen required to oxidize organic matter	6.40	.780
Chlorine	4.20	2.100

The degree to which the purification has proceeded (assuming that there has been no concentration or dilution of sewage from evaporation, subsoil water or other causes) is indicated by the following table:

Albuminoid ammonia	.93½ per cent.
Free ammonia	.88 " "
Nitrates	.56 " "
Oxidizable organic matter	.88 " "
Chlorine	.50 " "
Total nitrogen in the effluent	.21½ " "

Fig. 1.

Much more favorable results may be expected, of course, during the warmer weather. The intention was to ascertain the conditions at about the most unfavorable season.

Fig. 1 is reproduced from a photograph of the filter beds taken at the time.

The method of sewage disposal by sub surface irrigation (which is but a form of intermittent filtration) is applicable in so many instances that a more detailed statement of the process may be of interest.

The object sought is the intermittent distribution of the sewage immediately beneath the surface, preferably of lawns or other grassed areas. The purification at this point being as previously stated, most rapid and giving no offense to the senses. The requisite appliances are the following: A water tight tank or chamber to receive the sewage and from which it may be discharged at intervals and a network of agricultural tiles laid beneath the surface with open joints through which the sewage may exude.

Practice indicates that as the sewage comes from the house it should first pass into a small catch basin or chamber adapted to intercept the solid matters and grease from sinks, etc., passing from this into the tank proper from which it is discharged either by hand or automatically. The general arrangement of the system is shown in Fig. 2. From the collecting tank the sewage passes through a pipe with impervious joints to the irrigation field which may, if the conditions are favorable, be within 25 or 50 feet for single houses. The distributing pipes are of small diameter and should be laid about eight or ten inches deep. They should have a slight fall which is secured by laying them on lines closely conforming with the contours.

Special appliances are now manufactured for use in this system which serve to perfect the details, but the system may be constructed from materials which can be bought in almost any town.

The system as above described contemplates the disposal of solid matters from water closets and other matter usually discharged into sewers. Where applied to the disposal of liquid waste only as in connection with a system of earth closets it may be somewhat simplified.

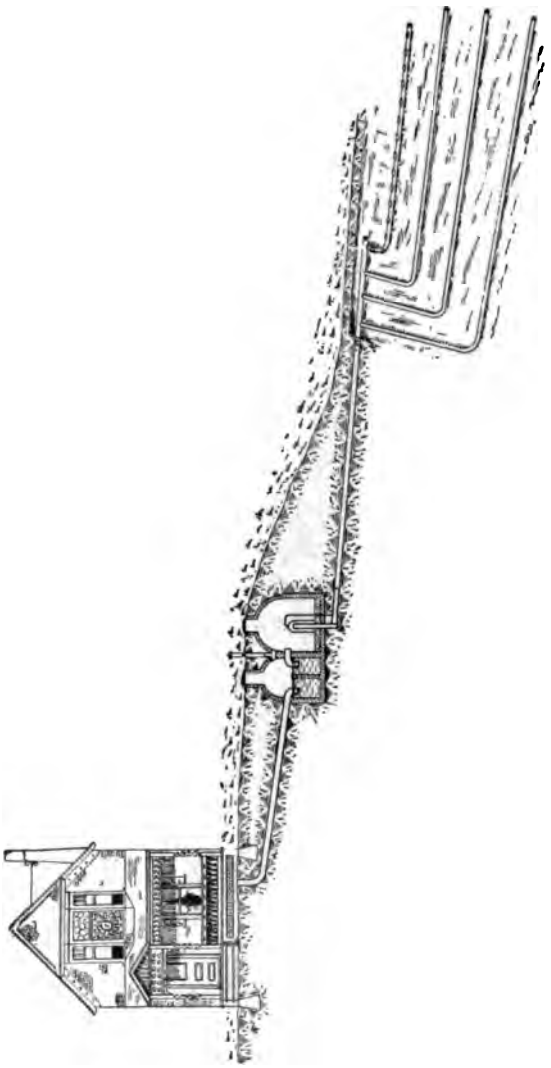


Fig. 2.

Fig. 2 shows the collecting tank fitted up with an automatic syphon by which the sewage is discharged at proper intervals without attention, a very desirable feature. The ordinary round agricultural tiles laid in special gutter pieces and covered at the joints with special caps to exclude the earth are generally used. The Y branches are designed to permit the escape of sewage completely from the main lines. A very good substitute may be made from common material as shown in

Fig. 3.

Fig. 3. Take ordinary hard burned bricks and lay end to end on the proper grade and at the proper depth. On these lay, as shown in the photograph, alternately, tiles of different diameter, inserting the ends of the smaller tiles in the ends of the larger. The larger tiles will thus serve the purpose of both the gutter and cover plates and the sewage will escape through the space represented by the difference in diameter of the pipes. If after some years it becomes necessary to take up the tiles and clean them the brick foundation need not be disturbed and the tiles can be replaced in their former position with little trouble.

Although it is usual when water closet wastes are admitted

to provide for the interception of the particles having a tendency to clog the distribution drains there will be but a slight accumulation in the intercepting chamber. The solid matter will by decomposition become so thoroughly macerated and dissolved that it will pass off in solution or in the form of small particles in suspension with the liquid. The comparatively small size of the intercepting chamber as compared with the quantity of sewage passing through it daily will prevent its contents from becoming offensive, especially as the chamber is set below the ground. In the case of a single cottage where earth closets are used the intercepting chamber and collecting chamber are sometimes dispensed with, which materially reduces the cost of the system.

Compact soils should be thoroughly under-drained to make them suitable for subsurface disposal. In the case of sandy or gravelly soils it is not necessary.

It is a significant fact that in the case of porous subsoils overlaid by loamy soils which are less pervious, a greater quantity of sewage may be purified by this method than by application to the surface over the entire area. In an experiment detailed in the report of the Massachusetts board of health before referred to, it was found that three times the quantity could be applied by this method with equal results.

The length of tile drains necessary to dispose of the sewage by this method varies from 50 to 200 feet for each person and in open, sandy soils, where the sewage from a large number of persons is contributed it may be less. This is on the basis of 50 to 100 gallons of sewage for each person daily. Ordinary residences properly fitted with modern plumbing and fixtures so that there is no extravagant waste of water will be amply served by 25 to 50 gallons.

The distributing tiles may be laid in lines about four or five feet apart so that the area necessary to serve as the irrigation field will be 250 to 500 square feet for each person. It is apparent therefore, that the ordinary urban lot of 4x8 rods with the area of lawn usually found in the smaller cities of this state will be sufficient for the purification of the sewage of the occupants. And that the area usually found convenient to

most summer resorts in this state which is available for such uses will suffice.

In practice it has been found that the sewage of from 250 to 500 persons can be applied to an acre of ground by this method continuously throughout the year and probably with the unusually favorable conditions to be found in the case of the northern summer resorts of this state where the season is of but a few months duration and the soil generally porous, this amount may be largely exceeded.

As an illustration of the application of this system let us assume the case of a northern Michigan summer resort. The resort will be open to guests from May to October at farthest. By reason of the fact that the soil will have long intervals of rest and also for the reason that at the season when sewage is applied to it the purifying agencies are most active, we may, with reason, considerably reduce the area of the absorption field below the standard which has been established for continuous use.

From results that have been obtained by this method it seems fair to assume that under the favorable conditions assumed one acre of ground will suffice for 1,000 persons and that if the sewage of even 1,500 persons be applied to an acre for limited periods at the height of the season it will still suffice.*

Assuming now a resort accommodating 200 guests there will be required about

2,000 feet of sub-surface drains @ 10c	$200 00
200 feet of carrier @ 25c.	50 00
Intercepting chamber	25 00
Collecting chamber	100 00
Automatic appliances	30 00
Miscellaneous	95 00
Total.	$500 00

It is doubtful if a resort not within reach of a system of public sewers can be better served than by such a system. It would undoubtedly be the part of wisdom for many resorts sit-

*Col. Waring states that the sewage of Lenox, Massachusetts, having a population of 800 to 1,200, is disposed of by this process on less than one and one-half acres of land throughout the year.

uated on water fronts and discharging the sewage along them to the offense of patrons, to adopt this method.

Those unfamiliar with this method are inclined to discredit the fact that sewage may be applied in this manner successfully in winter. It is an established fact, however, that where frost penetrates between the drains to the depth of several feet the sewage exuding from the drains keeps the soil adjacent to them open.

The sub surface system of disposal was first introduced by Rev. Henry Moule, the inventor of the earth closet, in 1868, to supplement the earth closet by the removal of the liquid matter. The growing popularity of the water carriage system of removal has influenced its development until at the present time it is held by leading sanitarians as offering the best solution of the problem of isolated sewage disposal.

PRESIDENT: Gentlemen, the paper is before you for your consideration. I would only remark that our friend, Mr. Pierson, exhibits a great deal of modesty in so quietly and unpretentiously making other people say those things he knows so well himself, and giving them the credit of knowing them, without taking any himself.

Remarks are in order from members. There are gentlemen here who have had experience in this matter. Would be glad to hear from them.

COL. MUENSCHER: I would like to ask Mr. Pierson if the result of his recent experiments was that in attempting to purify sewage by filtration, the larger surface exposed the better, that almost all purification is within the first few inches of the filter?

MR. PIERSON: That directly and logically follows. The number of bacteria decreases very rapidly below the first few inches.

COL. MUENSCHER: So, as long as you get a large surface, it is no great object to get a large depth. I have been a little surprised at the different results I have seen. How do you count these organisms? Do you use the microscope for making an estimate?

MR. PIERSON: Yes, I can find them, but I cannot count

them directly. It is done by distributing small quantities of sewage over surfaces adapted to the growth of bacteria. The number of colonies of bacteria which appear is a basis from which the number of bacteria in a given volume of the sewage may be computed.

COL. MUENSCHER: Do you find these organisms to be mostly animal or vegetable?

MR. PIERSON: Mainly vegetable.

COL. MUENSCHER: Don't destroy each other, do they, one vegetable destroy another?

MR. PIERSON: Well, they destroy organic matter; yes, they destroy each other. They dispose of organic matter.

MR. HODGMAN: The big fish eat the little ones.

OWNERSHIP OF LAKE BEDS.

F. HODGMAN.

Since my paper on this subject was read before this society, the Supreme Court of the United States has passed upon the question with reference to the ownership of a lake bed in Illinois in which they lay down the following principles:

1. That patents, by the United States, of lands bounded by streams or other waters, in the absence of reservation or restriction of terms, are to be construed as to their effect according to the law of the state in which the land lies.

2. In Illinois, the common law being in force, a patentee from the United States of land there situated, bounded by the water of a small lake, takes to the center of the lake.

3. Meander lines, as shown by the United States surveys, do not constitute the boundary. The water is the real boundary.

4. When a patent is issued for land bounded by a lake or stream, the title to the land under water passes from the government, and subsequent action of the land department in surveying and granting the latter land is without authority and void.

Hardin vs. Jordan, 2 Sup. Ct. Rep., 808.

The reasons of the court in coming to these conclusions are given at too great length for the columns of the Annual. The controversy was in regard to the ownership of the bed of Wolf lake, near Chicago. One party claimed a portion of it under the common law, claiming title through a government patent of adjoining fractional lots, and the other party claimed title from a subsequent survey of the uncovered lake bed and purchase from the government. In closing the case the court says: "On the whole our conclusion is that the court below should have given judgment for the plaintiff as against the defendant, to the center of Wolf lake, instead of to low water mark in front of 'certain lots' and to the middle of the bay or projection of the lake in front of 'a certain other lot.' If there should arise any question between the plaintiff and other riparian owners of lands situated on the margin of the lake as to the convergence of the side lines of the plaintiff's land in the lake, it can be disposed of by the parties themselves by a resort to such form of procedure as may be proper."

Three of the judges dissented from this, and as their opinion is comparatively brief and covers the points at issue it is reproduced in full from the Supreme Court Reporter for June, 1891:

HARDIN v. JORDAN.

(May 11, 1891.)

BOUNDARIES—PUBLIC LANDS—SMALL LAKES.

Under the laws of Illinois, a patentee from the United States of land there situated, bounded by the waters of a small lake, takes only to the water's edge. Per Brewer, J., dissenting. Gray and Brown, JJ., concurring.

BREWER, J. (*dissenting*). Mr. Justice Gray, Mr. Justice Brown and myself are unable to concur in the foregoing conclusions. Beyond all dispute, the settled law of this court, established by repeated decisions, is that the question how far the title of a riparian owner extends is one of local law. For a determination of that question the statutes of the state and the decisions of its highest court furnish the best and the final authority. In the case of St. Louis v. Rutz (decided at the

present term), 138 U. S. 226, 242, ante, 337, 343, it was said by Mr. Justice Blatchford, speaking for the court: "The question as to whether the fee of the plaintiff, as a riparian proprietor on the Mississippi river, extends to the middle thread of the stream, or only to the water's edge, is a question in regard to a rule of property which is governed by the local law of Illinois. Barney v. Keokuk, 94 U. S. 324, 338; St. Louis v. Myers, 113 U. S. 566, 5 Sup. Ct. Rep. 640; Packer v. Bird, 137 U. S. 661, ante, 210. In Barney v. Keokuk it is said that, if the states 'choose to resign to the riparian proprietor rights which properly belong to them in their sovereign capacity, it is not for others to raise objections.'" The cases referred to in this quotation affirm the same doctrine. If we turn to the decisions of the supreme court of Illinois, we find one rule laid down for running water and another for lakes and ponds. In the former case the riparian owner owns to the thread of the current; in the latter to the water line. No distinction is made on account of the size of either stream or pond. Without noticing the authorities in reference to rivers or other running water, it is enough to refer to the decisions in reference to lakes and ponds. In the case of Seaman v. Smith (decided in 1860), 24 Ill. 521, 525, it was held that a riparian owner on a large lake (Lake Michigan) took title only to the water line. The reason of that decision was thus expressed in the opinion of the court: "These great bodies of water, having no currents, like rivers and other running streams, cannot present the same reasons why the boundary should be extended beyond the water's edge, where it is ordinarially found, that apply to running bodies of water. Where such streams are called for as a boundary, the thread of the current is held to be the line from each side. Such a rule could not, for the want of a current, be adopted in this case. It would not be sanctioned either by analogy to the rule or by reason. And if the outer edge of the water be passed, owing to the approximation of these bodies to a circular shape, it would be found exceedingly difficult, if not impossible, to ascertain where the boundary should be fixed, or the shape it should assume." It will be perceived that the same reasoning applies whether the lake be a large or a small one. There is no decision or intimation by the supreme court of that state

questioning the rule thus laid down. Again, in 1886, in a later case (Trustees v. Schroll, 120 Ill. 509, 12 N. E. Rep. 243), the question arose as to a small lake, no larger than the one in controversy, and the same rule was applied there as in the case of Lake Michigan; and it was held that the title of the riparian owner stopped at the water line; and the case of Seaman v. Smith, supra, was cited as furnishing the authority and reasoning for the rule. Nor was this a mere casual or incidental remark in the course of an opinion. The opinion is some seven pages in length, and over four pages are devoted to a discussion and decision of this question. It was the principal and paramount question, fully reasoned out and obviously carefully considered. We quote as follows: "It is equally well settled that grants of land bounded by streams or rivers above tidewater carry the exclusive right and title of the grantee to the center of the stream, *usque ad filum aquæ*, subject to the easement of navigation in streams navigable in fact, unless the terms of the grant clearly denote the intention to stop at the edge or margin of the stream. 3 Kent Comm. 427; 2 Hil. Real Prop. 92; Ang. Water-Courses, § 5; Jones v. Soulard, 24 How. 41; State v. Milk, 11 Fed. Rep. 389; Canal Appraisers v. People, 17 Wend. 596; Child v. Starr, 4 Hill, 369; Seaman v. Smith, 24 Ill. 521: Rockwell v. Baldwin, 53 Ill. 19; Braxon v. Bressler, 64 Ill. 488; Ice Co. v. Shortall, 101 Ill. 46. But an entirely different rule applies when land is conveyed bounded along or upon a natural lake or pond. In such case the grant extends only to the water's edge. Angell, Water-Courses, §§ 41, 42; 3 Kent, Comm. 420, note *a*, citing Bradley v. Rice, 13 Me. 201, and Waterman v. Johnson, 13 Pick. 261. See also, Warren v. Chambers, 25 Ark. 120; State v. Milk, (U. S. Cir. Ct. Dist. Ind., Gresham, J.,) 11 Fed. Rep. 389; citing Wheeler v. Spinola, 54 N. Y. 377; Mansur v. Blake, 62 Me. 38; State v. Gilmanton, 9 N. H. 461; Paine v. Woods, 108 Mass. 160; Fletcher v. Phelps, 28 Vt. 257; Austin v. Railroad Co., 45 Vt. 215; Boorman v. Sunnuchs, 42 Wis. 233; Delaplaine v. Railway Co., Id. 214; and Seaman v. Smith, 24 Ill. 521. See also Nelson v. Butterfield, 21 Me, 229; West Roxbury v. Stoddard, 7 Allen, 158; Canal Appraisers v. People, 5 Wend. 423; Jakeway v. Barrett, 38 Vt. 316; Primm v. Walker, 38 Mo. 99; Wood

v. Kelley, 30 Me. 47." And again: "Indeed, the controlling distinction between a stream and a pond or lake is that in the one case the water has a natural motion—a current—while in the other the water is, in its natural state, substantially at rest. And this is so, independent of the size of the one or the other. The flowing rivulet of but a few inches in width is a stream as certainly as the Mississippi. And when lands are granted by the proprietor of both land and stream, bounding such grant upon the stream, the grantee acquires right and title to the thread or middle of the stream. This right is grounded upon the presumption that the grantor, by making the stream the boundary, intended his grantee to take to the middle of the stream: and this presumption will prevail until a contrary intent is made to appear. Rockwell v. Baldwin, 53 Ill. 19. The right spoken of does not rest upon the principle that when a grant is bounded on a stream the bed of the stream to the thread or middle passes as incident or appurtenant to the bordering land, for the bed of the stream is land, though covered with water, and land cannot pass as appurtenant to land. As is said in Child v. Starr, 4 Hill, 369; 'A conveyance of one acre of land can never be made, by any legal construction, to carry another acre by way of incident or appurtenance to the first.' The riparian proprietor, claiming to the thread or middle of the stream, must show the bordering water to be a stream, and that his grant, in terms or legal effect, is bounded upon or along such stream—that the stream is made the boundary." These quotations show that there was no mere inadvertent or casual remark, but that it was the distinct and well considered as it was also the unanimous decision, of the highest court of the state. We do not think it sufficient to overthrow the force of this decision to say that the common law of England was different—a proposition which, in passing, we may say we doubt; nor that there was another question in the case also referred to in the opinion, which fully justified the decision, and that, therefore, the discussion and decision of this question were unnecessary; for that other question was put after this in the opinion, and was evidently intentionally made subordinate to this. Believing that the law of Illinois has been determined by its supreme court, we think that determination

is conclusive on this court. As strengthening the views we have expressed, may also be noticed the opinions of the circuit and district judges in this very case, on separate trials (see 16 Fed. Rep. 823), both announced before the decision in 120 Ill. and 12 N. E. Rep., and agreeing that, under the laws of Illinois, the title of the riparian owner stopped with the water. The long judicial experience of those judges, and their familiarity with the laws of Illinois, give to these opinions great weight. We therefore dissent from the conclusions of the court.

ENGINEERING FOR CEMETERIES.

O. C. SIMONDS.

[Supt. of Graceland Cemetery, Chicago, Ill.

I was very much surprised yesterday when Mr. Skeels called upon me to say something to the engineers, and so made no special preparation, and I will talk to you in a haphazard way about engineering in cemetery matters. That is what Mr. Skeels asked me to speak of, and if I fail to touch upon any point of interest, I will be very glad if you will interrupt me with any questions.

In the first place, the land selected for cemetery purposes should, for manifest reasons, be of a porous nature, and have a good natural drainage. After the land is selected the first thing in order is to locate the drive ways. These should be located so as to make it as convenient as possible for a person to reach any given point from the entrance of the cemetery, and that would make it necessary that the drive ways, starting from the entrance, should branch out in easy curves, following the lay of the land to some extent, and dividing the whole area into sections, elliptical in shape and having the shorter axis in every 100 feet. We have been taught how to lay out curves of various kinds, circular, parabolic and other geometrical curves, but when a person comes to lay out curves in a park, he ought not to attempt to show his skill in laying out geometrical curves. A curve laid out by the eye is always more pleasing

than one based on geometrical principles. Of course the topography will influence the drive ways, so a map is necessary. The best instruments to use in obtaining such a map are the transit and stadia—the method with the stadia being more correct than where it is divided into rectangles.

After locating in a general way the drives, the method usually employed now to exactly locate the drive way, is to take a bundle of sticks, putting them about where you would like to have the drive. I usually put the sticks on one side and stand away, having a man to move the sticks until I get a drive way satisfactory to my eye. After you get one line it is a simple matter to measure across and locate the other line. The width of drives is usually from twenty to thirty feet. Twenty feet is rather narrow, because people are always attempting to turn, and that scarcely gives room to turn, without encroaching on the sides. Thirty feet I consider ample.

In regard to grades. Gilmore recommends a longitudinal grade of not less than one foot in 125, and not more than six feet in 100. If possible, get some fall or rise to a street so that the water will run lengthwise, and you will always find that you can keep your streets drier, than if you have the center line perfectly level, and it is more pleasing to the eye. Avoid all useless curves. Never put in a circle so a person feels he is going out of his way.

After the drive ways are located and the grades are established, it will be necessary to grade the land on either side no doubt. You should try to avoid grading as far as possible, because if you use the natural surface you have the natural soil, and if you disturb it you never can get quite so good soil as you have to begin with.

Frequently we use too much engineering in cemeteries. If we look along a drive, we see something that looks like a railroad embankment. We should always try to imitate nature, and get natural curves. Mr. Strauss, the leading landscape gardener in his day, said one time that the surface of the drive should be tangent to the roadway. For instance, if the section adjoining the road is higher than the roadway, the immediate surface along the drive should be concave. Start out level and gradually rise up. If the ground is lower than the street, of

course the surface should be tangent and gradually fall. However the drives should be in the low land if possible. You always measure the height of land with the driveway as a basis. If the land is higher than the drive, "this is high, nice land," but if lower than the drive, you get a low piece of ground. This is of advantage in draining the sections also, and of course the drives will need drainage by means of sewers, and so you take care of all the water in one location.

After the drives and sections are graded, the next thing in order will be planting trees. That is not usually considered a matter of engineering, but nearly all men are called upon at some time to plant trees, and so I will just state a few points that should be taken notice of. You should always avoid planting a tree lower than it stood before being moved. It looks bad to see trees standing in holes, and not only looks bad, but is bad. It is bad in appearance, and if you cover the roots afterwards, it is almost certain to die. A tree needs air. The first thing I would say then in planting a tree, would be not to plant it too low. About Chicago it is very common to plant trees of large size. They are usually dug out with a large mass of earth attached and that is rolled onto a wagon something like a stone truck. The trunk of the tree is bent over and rests on a support by the hind axle. The danger here is that the bark will be injured where it rests on this support, and still trees are moved very successfully in that manner. We have moved some trees of quite large size, nearly three feet in diameter, in a different way.

The trees have been undermined and timbers run through underneath. Then laying timbers under these, and the whole tree has been raised up in its upright position with jack screws, just as you would raise a house, and then the tree has been moved, just as you would move a house, with capstan and chains. Some trees we moved had a spread of sixty feet, and grew with almost as much vigor as though they had not been moved. These trees I speak of now were only moved a short distance. There is danger in moving such a large tree in an upright position, that the wind may blow it over, and so in moving the last large tree I had a hole made right through the tree. Many people seem to think that because if you injure the heart of a

man he will expire immediately, if you injure the heart of a tree it will die, but the life of a tree is in the bark, and many times a tree will live for years and years without any heart at all, and so I anticipate that the hole which we made through the tree, and through which we put an iron bar, will not injure the tree; not nearly so much as taking off the bark where it might rest on the wagon. This tree weighed, with root and dirt, something like forty tons, so we never could have moved it on a wagon.

MR. APPLETON: Will you tell us the variety of these trees.

MR. SIMONDS: All these large trees that have been moved in this way are elms. They have roots spreading out near the surface of the ground.

MR. APPLETON: Did you ever try oak?

MR. SIMONDS: The oak tree cannot be moved in that way if it is a great size. We have moved oak trees perhaps five or six inches in diameter, but we never attempt to move an oak tree of any larger size.

MR. APPLETON: Hickory trees?

MR. SIMONDS: No, you cannot move hickory trees; but you can move maples, lindens, elms, iron-woods.

MR. APPLETON: Usually move those large trees, don't you, in the winter, with the leaves off and frozen boughs?

MR. SIMONDS: All trees should be moved when the leaves are off, but it isn't necessary to have a frozen bough. If I can have the roots well taken care of, and the dirt remain, I would rather move it in warmer weather.

MR. APPLETON: I have had some experience, and in porous soil, you lose the soil too much.

MR. SIMONDS: Yes, in such case, it is better in the winter. But I remember one tree moved in the winter, and during the moving of the tree we had some very cold weather, and the roots were killed all around, about two or three inches. So if you can move trees when there is no frost in the ground, I think it is preferable.

COL. MUENSCHER: Were you trying to get the entire root?

MR. SIMONDS: We get all the roots we can, and then when the tree is planted, the ends of the roots should be cut off.

COL. MUENSCHER: In moving these trees of such large diameters, you put rollers under it?

MR. SIMONDS: Yes, just like a house.

MR. STEELE: I have noticed in this gentleman's remarks that he didn't pay any attention to a geometrical figure on the ground. How is it he would describe his lots? How are they bounded, and what method is used to plat or define them?

ANSWER: I omitted to say anything about the subdivision of a section into lots. The way we have done in making plats and surveys, is to first stake out the drive, and then survey it, and then we stake out lots with the sides at right angles to the line of the roadway, putting large lots near the drives and smaller lots in center sections. In some cemeteries all are the same size, but the wishes of purchasers vary, and you can get better effect in this way, so you keep breadth along either side of your drives. Now these lots are surveyed and platted with the same accuracy that rectangular lots would be.

MR. STEELE: That is the point I wanted to get at How can you, your curves are not regular at all?

MR. SIMONDS: Many of the lots are rectangular, but suppose we had a lot fronting on a curved street, the sides might be straight, but the front curved, and that would be defined by a straight line joining the two corners next to the driveway.

MR. STEELE: You then would describe a curve of a short arc, and find the ordinate?

MR. APPLETON: In regard to the alleys. Of course you put alleys between lots. How broad do you use?

MR. SIMONDS: We have no alleys. We have what we call walks, but you would not detect them. The lawn is continuous and these walks are simply spaces, covered with grass, same as the lots, and they are not followed by people in going over the cemetery. If a man wants to go from one point to another, we have no difficulty in having paths for them over the lawns. These walks serve a purpose. If we wish to carry material, we can follow these walks, and so not trespass on people's lots, but visitors are not expected to follow them, and usually do not.

I mentioned that sections should be elliptical. The walks should generally be transverse. Of course you have some

walks in the other direction, but you should always be able to come out at one side of your ellipse and reach the driveway.

MR. STEELE: And as to the width of these walks?

MR. SIMONDS: We usually make the width three or four feet. When the cemetery of which I am superintendent was first laid out, the walks we made ten feet wide, but it was a great waste of land.

MR. APPLETON: We found that with less than eight feet the wheels of the wagons loaded with marble cut into the lawns, and that is very objectionable.

MR. SIMONDS: Stone men are never allowed to drive in a new section. They simply follow the drives, and then wheel in the marble.

MR. APPLETON: Then you have small sections?

MR. SIMONDS: We have some six or eight hundred feet long; but we don't want to destroy the beauty of the cemetery for the convenience of the stone cutter.

MR. APPLETON: A very expensive twenty ton monument, for instance, requires some mechanical means for getting it there?

MR. SIMONDS: Yes, but that cannot be done with horses and wagons.

MR. : There was one matter connected with Mr. Steele's question: Do you furnish each person a plat with his deed, or is there a plat on the back of his deed, or in what manner do you indicate to the individual the written evidence of the location of his lot?

MR. SIMONDS: We give any one a plat that asks for one. We usually give the purchaser of the lot a plat of the whole cemetery, and the lots are numbered and the description calls for lot such a number in such a section.

MR. : That is customary, and in some cemeteries they use a form, upon the back of which is printed a plat of the cemetery.

THE PRESIDENT: Any more questions you would like to ask Mr. Simonds? If not, the next thing for our—

Motion made and supported to tender the thanks of the Association to Mr. Simonds. A unanimous vote.

REPORT OF COMMITTEE ON QUESTIONS OF PRACTICE AND DISCUSSIONS.

Your committee would respectfully report the following questions submitted to them, and the answers adopted:

No. 1. Should the surveyor endeavor to locate an error in an old plat, which error must otherwise be treated as surplus or shortage?

ANSWER. Yes. In case the plat was made from an actual survey, in which the lots were marked out upon the ground,—an evident error in the plat would be controlled by the survey, and the subsequent surveyor should endeavor to locate the lines just where they were originally laid down. In case the plat was made without a survey, the surveyor should endeavor to lay down the lines so as to comply with the prevailing intention as shown by the plat itself. A line laid down as a straight line in a plat might prevail over an erroneous distance which would make the line a crooked one.

No. 2. Should a ditch for drainage purposes ever be laid in curves instead of straight lines with angles?

ANSWER. Yes. The tangents should always be connected by curves and no sharp angles permitted in the line of the ditch. As a rule, the radius of the curve should be short, because of the inconvenience of working land on a curve.

No. 3. Having the bearing trees to a section corner, one or both standing near the line and at a considerable distance from the corner, how shall I locate the corner?

ANSWER. Circumstances will alter cases. No rigid rule can be given. In a general way, find the meridian, and measure (or length of chain) of the original survey as nearly as can be done under the circumstances; locate the point accordingly, and then dig for the corner stake, availing yourself of every bit of evidence that will throw any light on the location. Mr. H. F. Bean suggests that the location of the line may be determined very closely by calculating the latitudes and departures of the bearing trees from the corner, and running

and measuring off the appropriate distances from the bearing trees. For instance, suppose the corner is located in a marsh and the bearing trees on its margin both standing are described as N. $\frac{1}{2}^{\circ}$ E. 11.90 chains, and S. $1\frac{1}{4}^{\circ}$ W. 12.60 chains.

A measure of $10\frac{3}{4}$ links west from one bearing tree, and $27\frac{1}{3}$ links east from the other will approximate very closely to the original line, and a pro rata measurement between the points thus located will come very near the corner.

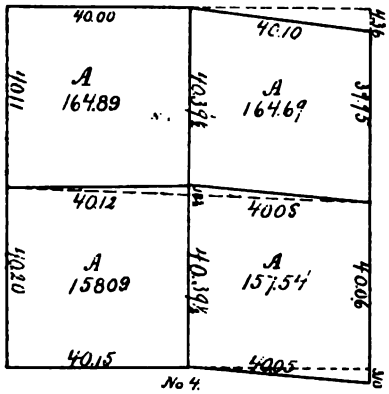
No. 4. See cut No. 4. In running the E. and W. $\frac{1}{4}$ line straight, the N. $\frac{1}{2}$ of the section will contain about fourteen acres more than the S. $\frac{1}{2}$. Subdividing the N. E. $\frac{1}{4}$ into halves in the usual way, the west part will contain 2.27 acres more than the east. What is the proper method of subdividing this section to do justice to parties claiming equal portions?

ANSWER. If the conveyances are made in accordance with the system of the United Stated surveys, the lines must be located accordingly. The quarter lines will be straight lines from each quarter post to its opposite corresponding corner, whether the section lines are straight or not. If parties claim equal areas they should show by their chain of title that they have a right to it, in which case the lines should run accordingly.

No. 5. See cut No. 5. In surveying the N. W. $\frac{1}{4}$ of a section I found the dimensions as in the figure. One deed calls for the W. $\frac{1}{2}$ and the other for the E. $\frac{1}{2}$ of the N. W. $\frac{1}{4}$. The quarter section purports from the official plat and U. S. field notes to be 160 acres. How should I draw the line between them?

ANSWER. The answer to No. 4 applies also to this. If the conveyances are in accordance with the United States system of surveys the line will be drawn midway between the quarter line and the section line. It may be necessary to trace the title back to determine this question. If not conveyed on the U. S. system then equal areas should be given.

No. 6. See cut. Assuming the quarter post of section 32 to be properly placed, would it not be in accordance with the act of Feb. 11, 1805, to take the half sum or half difference of the distances apart of the section corners for that of the quarter posts? The corners of section 5 are regulated by those of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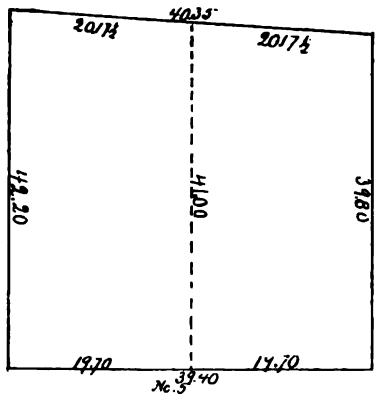
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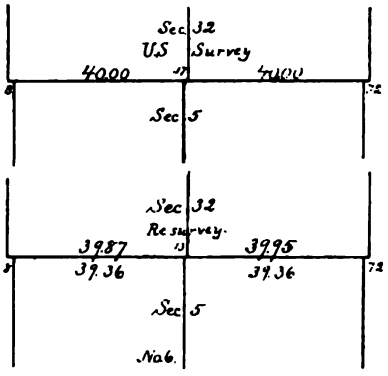
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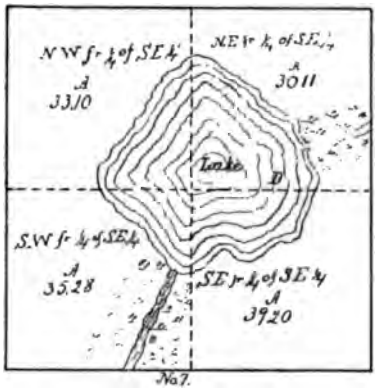
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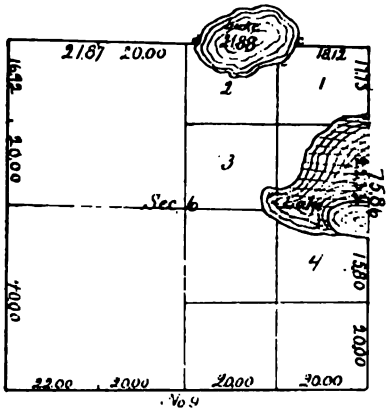
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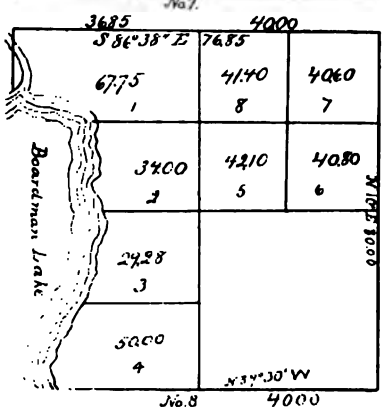
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Boardman Lake
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N 34° 30' W
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section 32. Why not determine the quarter post in the same manner?

ANSWER. This is open to discussion. The government field notes do not return the distance between the N. E. and the N. W. corners of section five. Under the old system of surveys no quarter post for that section was planted on its north line, and according to law it must be planted midway between the section corners. We do not think that the recorded measure of the south line of section thirty-two should control the measures for locating the north quarter post of section five. The corners of section five are not regulated by those of section thirty-two, except as to line, any more than the corners of thirty-two are regulated by those of five. If the returned distances between these corners do not agree with our measure we cannot move either corner to make them agree.

No. 7. See cut. Four persons own as shown in the cut. The lake has dried away. The last seen of the water was at *D*. Do the owners follow the receding waters till it is gone; or do they stop at the limits of their full descriptions as forties?

ANSWER. The Supreme Court of the United States claims to follow the decisions of the local courts in such cases. The Supreme Court of Michigan decided in Clute vs. Fisher that boundary lines extend along the land under water the same as if there was no water there. The chairman of the committee thinks our court is wrong in this, and that it will ultimately be compelled to lay down a different doctrine and reject this one, for reasons given somewhat fully in the paper on the ownership of lake beds published in last year's Annual.

No. 8. See cut. How shall I run the east and west quarter line of this section eleven?

ANSWER. The instructions of the land department are conflicting in such a case as this. The rule which they lay down, to subdivide in such a way as to suit the calculation of the areas given on the official plat, would seem to be an equitable one in this case.

No. 9. See cut. How shall I subdivide this section six? The figures on the lines represent the government measure. My own measures are:

From S. E. corner north to meander post on south side of lake	40.00 chains.
From same meander post to N. E. corner of section	39.06 "
From N. E. corner west to meander post E. of lake	17.80 "
From same meander post west to quarter post	22.42 "

There is no meander post on north side of lake in the east line. All the other corners are standing all right. The shaded and cross marked part of that lake is upland, and the lake is only 6.00 chains wide on the east line of the section, instead of 22.33 chains, as returned in the field notes.

ANSWER. On the east line of the section the measure between the meander post and the N. E. corner should be prorated; also, the measures on the north line between the meander post and the quarter post. Subdivision should then be made in accordance with the rules for subdividing section six.

F. HODGMAN,
H. A. COLLAR,
GEO. S. PIERSON,
Committee.

DISCUSSION.

MR. HODGMAN: Referring to the question No. 7, perhaps I cannot do better than to quote the following from my last year's paper in giving my reasons for objecting to the decisions of the Michigan and Indiana courts:

"We now come to the question of how the boundary lines shall be extended or located in the lake beds. The answer depends almost entirely on the question of title. If the title of the abutting owners stops at the water's edge, as held in the cases cited, in case the water recedes, the boundary line will be extended according to the laws governing accretions, which are supposed to be familiar to the members of this Society. (See Manual of Land Surveying, Fifth Ed., p. 279.)

"If, on the contrary, the abutting owners own the lake beds also in the manner held in Clute vs. Fisher and Stoner vs. Rice, then the boundary lines are to be located on the same principle as if there was no water there. This view of the case does not seem to me to be sound or just, as a general principle

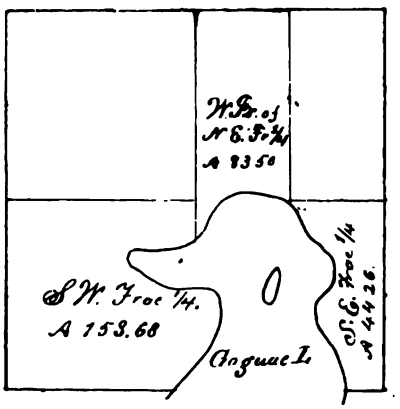
or rule, while at the same time in many cases it would be a very convenient rule, and do no special harm; but,—

"1. The government did not sell the land that way. It has never been conceded by the land department that they sold the land under the waters of meandered lakes. When the lake is not meandered, they sell it, and charge the purchaser the same price per acre that they do for the upland. Would it be just to make one man pay for a lake which is not meandered, and give to another man for nothing the lake that is meandered? It was not so intended.

"2. There are hundreds if not thousands of cases in which this Michigan and Indiana rule cannot be enforced without disturbing vested rights which have been thoroughly settled by the courts. There are fifty or more such cases in my own county alone. The act of 1820 (R. S. 2397) provides that fractional sections shall be subdivided into quarter-quarter sections under such rules as may be prescribed by the Secretary of the Interior. Under that statute, the Secretary of the Interior prescribed rules directing that such sections be divided by north and south or east and west lines, so as to preserve the most compact and convenient forms. It has been definitely settled that these rules were valid and lawful. (See Gazzam vs. Phillips lessee, 20 Howard 372.) Under these rules it has been the custom of the land department ever since to divide these sections so as to preserve compact and convenient forms. In doing so they have frequently attached small outlying fractional lots to an adjoining larger tract, and sold the whole by a description derived from the larger tract. These outlying fractions have not always been in the same section, or even in the same township, as the tract with which and by name of which they were sold.

"Take, for instance, Section 14 in the township of Battle Creek, Mich. The cut gives a correct idea of the official plat of that section, and the manner in which it was sold. Goguac lake lies partly in the section, and has an island lying wholly in the southeast quarter. This island was meandered and sold by itself, and has ever since been occupied by the grantees who derived title from the United States Government. There is a tract of several acres lying west of the lake and east of the

north and south quarter-line which is entirely separated by the lake from the rest of the southeast quarter. It was attached to and sold as a part of the southwest fractional quarter. The north and south quarter-line was not extended across this tract on the official plat of this section. There is another small tract in the southeast quarter, but entirely cut off from the rest of that quarter by the lake. It was attached to and sold as a part of the west fractional half of the northeast quarter. The remaining tract lying east of the lake was sold as the southeast fractional quarter. Now, suppose we attempt to apply this new Michigan-Indiana rule to this case, and see how it works. If as in Stoner vs. Rice, the purchaser of the southeast fractional quarter is entitled to the entire quarter section, he must take away the island from one man, and the tract north of the lake from another, and the tract west of the lake from another, in order to get what belongs to him. But the Supreme Court of the United States (Gazzam vs. Phillip lessee) says that cannot be done, and the Supreme Court of Michigan too (Wilson vs. Hoffman, 38 N. W. Rep. 558), says that cannot be done. Then what becomes of the principle laid down in Stoner vs. Rice? and how are we to determine the boundaries of the island and these outlying fractions on the principles laid down in Clute vs. Fisher? That cannot be done either. The only way such cases can be rightly adjusted, is on the grounds that the owners of the abutting tracts do not own the bed of the lake. But it may be said, This is an exceptional case. Not so; on the contrary, it is a very common case. The township of Ross alone, in Kalamazoo county, has sixteen tracts of land similarly situated.



"Lastly, we may refer to the official plats of the government survey as having some bearing on these questions: 'Lands

are not surveyed lands by the United States until a certified copy of the official plat has been filed in the local land office.' (United States vs. Curtner, 38 Federal Rep. 1.) This official plat defines the location and boundaries of the various tracts into which the section is subdivided. In Gazzam vs. Phillips lessee, the Court tells us the sales to Stone and Etheridge 'were in conformity with the official plat then on file in the local land office.' It determined the extent of their grants. This is the regular course in all government sales of the public lands. Now I find in all the official plats that I have examined, and I assume that it is the same with most if not all of them, that *no part of a meandered lake is included within the marked boundaries of the abutting tract*, and hence is not included in the sales of those tracts. On the official plats, neither township, section, nor any subdivision lines are extended across these lakes. They are entirely segregated from the surrounding tracts."

MR. GREENE: The interpretation of this case seems to me to depend upon the conditions of the grant, like all others. What does the patent say, how is it worded and what is the description? They speak here of the southeast fractional quarter and the west fractional half of the northeast fractional quarter. If this decision just referred to is correct, there is no southeast fractional quarter, it is a full quarter. If this man owns around here, he owns the southeast quarter, and the patent ought to say so, but it does not. It was the intention of the government to grant the fractional quarter. But it is the grant itself that determines the intention of the parties. If you make a deed and describe the land, you are not to go all over the State of Michigan to ask people what they think about it, and a patent is still more in force between parties. It is the government that is parting with its title, on which title all the subsequent purchasers base theirs. So it would seem to me, that consideration alone would show that position to be very weak.

MR. HODGMAN: They practically, by that decision, decide that the word fractional has no meaning whatever as applied to lands bordering on water.

Mr. Steele called attention to question No. 8. [Since the

convention he has sent a copy of the government plat of the section, showing it much more fully than was done by the gentleman who submitted the question. It is from Mr. Steele's plat that the cut is made. He also sent the following statement, which is here given in place of the remarks made in the discussion:]

"In July, 1869, I subdivided this section for Mr. Barlow, who owns lot five and the N. W. ¼ of S. E. ¼. He is now kicking because the N. W. corner of lot five is not further north so that his house, which is in the street, would not have to be moved. I judge that having acquiesced in this survey so long, he would now be estopped from claiming under a different one. Two years ago, I platted lot one, using my old corner at the S. E. This year I wanted to use the N. E. corner of lot four. This and the center being all torn out, I commenced at the S. E. corner of lot one and twice measured the distance to the south quarter post, giving each lot one-third of the distance. The result in feet was as follows: The S. E. corner of lot one was $1354\frac{3}{10}$ feet from the north quarter post. Each of the other distances was found to be $1351\frac{3}{10}$ feet. The rule of intermediate courses was so nearly preserved that I could not better apply it. You will notice that the area of lots in the N. E. ¼ is not reliable. If both E. and N. lines were made 40 chains originally, how could lot eight = 41.40 and lot five = 42.10? or lot six = 40.80 and lot seven = 40.60? I discarded these and took the government distances. By these it is shown that the E. quarter post bisected the E. section line, and that both N. and S. quarter posts were set at exactly 40 chains from the section line."

I depend more on distances given in the field notes than on areas given in the plats. I suppose the areas are derived from the distances, and that hence the distances should govern.

MR. MEIGHAN: The deputy surveyor don't make those calculations in the field. The draughtsman is the man who computes the areas and puts them on the plats, and it seems to me that the correct way would be to take the original distances, and compute from them, and if you can't make them agree let it be as near to the original areas as the proportion will make it.

MR. GREENE: If those distances are not there, I would say

Mr. Hodgman's answer is correct, but having them, I think it should be modified.

MR. HODGMAN: Of course if we could have had the official plat here, it might have modified the answer very materially. But we did not have it, and could only answer in the light of such facts as were given us. In the light of Mr. Steele's statement, the question so far as that section is concerned is no longer an open one. The survey made by him, in 1869, was in exact accordance with one of the rules laid down by the United States land department in regard to the use of intermediate courses, and having been acquiesced in so long, it is now too late to raise a question in regard to it, if it ever could have been done successfully. But suppose it were a new question now, to be settled for the first time. The land department sells such lots as these in accordance with the official plat. The filing of a copy of the official plat in the local land office is an indispensable preliminary to the sale of the land. Legally, the land is not surveyed until this plat is filed. There is this much to be said in favor of the other rule laid down by the United States land department. Each purchaser bought and paid for the quantity of land marked down for his lot on the official plat. The purchasers of lots 5, 6, 7 and 8, bought and paid for 42.10, 40.30, 40.60 and 41.40 acres respectively. Now, if the land be subdivided so as to suit the calculations of the areas of these lots as shown on the official plat, each man will receive his proportionate share of what he bought and paid for. Substantial justice and equity will be done to all of them.

In regard to the statement of Mr. Meighan, that the surveyors in the field did not make the estimates of the areas, that is true now, but it was not always true. There was a time when the surveyors in the field made these estimates. The Surveyor General of the district of Illinois and Missouri, in his instructions to his deputies, printed in 1856, states that "some of the areas seem to have been calculated in one way, and some in another, and some would seem not to have been calculated at all." They were just simply put down by guess, just as some government surveyors in Michigan put down surveys on paper, that they never made on the ground.

PRESIDENT: Gentlemen, what will you do with the ques-

tions that the committee have answered? They are at your disposal for adoption or rejection.

MR. TODD: Mr. President, I would suggest that the last answer would rather contradict the answer to question No. 6, that has been given. The same question is involved. Whether a point, known and marked on a government survey, must be held as in existence, or can be ignored. We have in this case to determine the quarter section corner, which never was set, but we have a point, known as the meander corner, and in setting points between the meander corner and the section corner reference must be had to the meander post, and by the same reasoning the quarter post for section five should be set in reference to the quarter section corner of the adjoining township.

I know that this society has held before, when this matter has come up, that the quarter section corner on the adjoining section has no reference in determining the position of the other quarter section corner; but it is a plain proposition that the thing is equal to the sum of all its parts; therefore, I would beg leave to dissent from the finding of the committee on the question of the quarter section corner. I am of the opinion that it should be located from the quarter corner of section thirty-two, provided that can be identified.

F. HODGMAN: Mr. Todd's remarks illustrate the opening sentence of the answer to that question, that "this is open to discussion." The committee gave their views and still adhere to them.

MR. TODD: I would very much like to hear this matter discussed. It is causing a great deal of trouble where I am from, and there is a great deal of money at stake in the matter, and I wish to be correctly informed as to the proper method of establishing these corners, and it is at the request of a good many land owners of that county, that the society discuss that question, and I think the decision of the society will have great authority in any law suits that may occur.

PRESIDENT: Any other gentlemen wish to speak on this subject?

MR. HODGMAN: The view the committee takes is this: That while it is true, as Mr. Todd says, that the whole is equal to

the sum of all its parts, still to make it true the several parts must be all expressed in terms of the same kind of measure, and not mix up two or more different kinds of measure, aggregate them and call them the sum of all the parts. You might as well say two feet and two links make four feet or four links. Now the surveys and measures of section thirty-two and section five are two distinct and different surveys made, possibly, years apart, by different men, with different tools, and under different circumstances, and while their measurements are all given in chains and links, they are actually different things on the ground. The survey of the south line of section thirty-two is one consistent whole thing of the same survey, the parts of which may properly be aggregated. Not so with the north line of section five. The length of the north line of section five is not returned. There is nothing in the returns to show that it ever was run by the government surveyors. They tell us they ran west on the south line of section thirty-two, but not a word do they say about the north line of section five. When they ran north on the west line of section five they say, "*north between sections five and six,*" showing that the measurements and the corner posts on that line were common to both sections. So they did in every case where they were intended to be common for the sections on both sides of the line. Now, if we are to use the quarter post of section thirty-two to locate the quarter post of section five from, we must assume that the jogs given in the field notes were run and measured as a part of the north line of section five, and that the measure is similar to that returned for the south line of section thirty-two. There is nothing in the instructions to Surveyors General, nothing in the field notes as returned, and nothing in the facts on the ground to warrant any such assumption, and not a word in the law which will warrant us in using such an assumption to override the plain words of the statute directing how such corners shall be located. It comes very handy sometimes, and I have located a good many corners that way myself in my earlier practice, but I learned that it led me into grave errors. In 1869 I located the north quarter post in section six in my own township by measuring over from the quarter post of section thirty-one the amount of the jog between

section corners as returned in the field notes. A few years after I found that the jog was not correctly returned in my notes and I had to do my work all over. I was lucky not to be sued for damages. A case occurred in section five of the same town which would have been similar if this case had not forewarned me. Having learned by it that the jogs at the N. W. corner of section five were not correctly returned, I investigated them at the N. E. corner and found a still greater discrepancy. In one case the discrepancy was twenty-eight links, and in the other one hundred and fifty-two links. After that I never mixed up two different kinds of measure in the same line.

MR. SKEELS: I was going to refer to an occurrence of that same kind, where one jog was one hundred and fifty links at one corner, and something at the other. At the one corner where it was reported to be one hundred and fifty links, it was only fifty links. Both corners were standing and the bearing trees were all in place. It has been my practice to measure the mile at the north side of the town, and set the quarter stake in the center of the distance. I think it is the only proper way to do the work.

COL. MUENSCHER: It seems to me that in a case of that sort you should not allow yourself to be governed by any distances which were not intended for that use by the government survey. You should use them only for information. Now, these jogs—those distances don't govern the location of any stake. They are governed by the witness trees, and you are not at liberty, if the witness trees remain, to use these distances to fix the corners, but where the distance is given as fixing the point, then you must be guided by them.

MR. SKEELS: I am something of a crank; but for the information of the young members of this association, would say that we have been plowing a certain part of this field three, four, five, or six times. Members familiar with the former proceedings of the Association and discussions, know this to be so. Now, new members, if they haven't the proceedings of the former conventions, if they will provide themselves with Mr. Hodgman's Manual, will find most of these questions discussed and answered, or so nearly so, that they can from that information proceed to do their work in such a way that even

if the courts follow them right over the ground they will, in nine cases out of ten, find that the work is correct. Now, if you will please accept this in kindness, and look the matter up, you will be very much surprised to see the amount of information in that Manual. Take it in your pocket with you on all work, and it will save a large amount of trouble, and of discussion also.

MR. HODGMAN: I want to thank Mr. Skeels very kindly for his good words for the Manual; but that Manual is a part of the work of this society. Mr. Skeels' remark is true. We are plowing this ground three or four times over, but we have got to keep plowing it if this society goes on. Now, as Mr. Skeels says, we have a good many new members, who have come into this society since these discussions have all been gone over. They haven't the reports and can't get all of them. Some of the most important papers cannot be had now. Others can. But it is just like the children in our schools. One class comes up and takes its degrees, and others take their places, and the teachers have to keep going over the same lessons year after year.

MR. TODD: I don't know but I am misunderstood in some of my remarks, but I believe I am a charter member of this organization, and Mr. Hodgman's report I have the greatest respect for, but I never will accept it as authority on anything in which I think Mr. Hodgman may be in error. I hope to be excused for bringing things before the society on which I may be in ignorance.

MR. HODGMAN: You are right, Mr. Todd. Keep doing it. We have got to keep doing it.

MR. BEAN: This jog business has been discussed a good many times, whether to divide by actual measurement, or proportional distances. The government did not run quarter lines at all. Now, we are told in restoring any measurement, at any point between two posts that were used by the government, that we must use proportional distances, that we must make our measurements conform to theirs. I think if we would do that, it would hit this case.

We will say for comparison that we measure the east forty chains and make it just as the government did. Go to the

west, and come down and find we don't get there into twenty links. Now, where will our point be? In fact, it is a jog of ten links on our own measurement. It is equivalent, I think, to leaving our measurement in conformity with the government measurement. Supposing there were no jogs at either of the corners, should there be a jog at the quarter post?

MR. STEELE: The north line of section five was decidedly bent at the quarter post which belonged to section thirty-two. I was in somewhat of a puzzle to know what to do, because if I ran a straight line between its own section corners, I would have a triangular piece of ground between the lines. I knew at once that could not be done, so I decided to bisect the line, and set the quarter post for five on the broken line, on one side of the quarter post for section thirty-two, and although I have never had a broken line before to establish, I have several times bisected the north line of the fractional section and used a quarter post for line. If I have been wrong in that I would like to be corrected.

PRESIDENT: Gentlemen, I have to discuss these questions in a great many ways. This is the doctrine I have settled down to. Mr. Steele asks if he was right. Yes. In these questions relating to closing corners, I hold this: That when the original corners were set, the township line was then marked and defined. It was there, and it is useless to talk about setting closing corners afterwards, to define or change a line that has already been defined and marked.

So, if you want to find a quarter post on the north or west side of a section where the government surveyors set none, that quarter post must be set equidistant and on the original township line as it was first run and marked.

As far as the jogs are concerned, pay no attention to them whatever, except in finding the location for the corners of the section itself. Then work directly from those corners. This is plowing over old ground, but I have stated the thing accurately and with as few words as possible.

MR. STEELE: The question that Mr. Hodgman answered with regard to the figure on the board was not decided as I understand. Mr. Todd raised an objection to the decision of the committee, and that was pending while you took the chair.

MR. TODD: The question I raised was not this question. It was in regard to locating the quarter section corner. It involved that question. The point I was trying to make was: In their decision in this matter, in refusing to go beyond the meander corner, they were taking opposite ground from their decision in the other, in ignoring the mark placed upon the township boundary, as being a certain distance as given in the government field notes, but in this case they take the meander point and regard that point as immovable.

MR. HODGMAN: I wish to note what I think is a little distinction. In this case the meander post is established by the government survey for that section as a point on the line, and its distance is given from the section corner. In the other case the quarter post was not established for section five and never pretended to be, and nothing is said about how far the post that was planted is from the corner of section five.

MR. STEELE: The question properly before us then is the adoption or amendment of the report of this committee.

SECRETARY: There is no motion.

PRESIDENT: I am prepared to entertain a motion, gentlemen.

MR. SKEELS: I move the acceptance and adoption of the report on inquiries.

PRESIDENT: It is moved and supported, etc. Are there any remarks?

The motion is carried.

OHIO BOUNDARY.

PRESIDENT: We will listen to the report of Mr. Steele on the subject of the Ohio boundary.

MR. STEELE: I think on that subject I am about as nearly blank as on the subject of the World's Fair.

We have had that question of the boundary line of Michigan and Ohio up before the Association before, and I recollect one member took especial interest in it, and gave us some information on the condition of things down there, the sum and substance of which is that people along the line between Michigan and Ohio don't know just where they live. Of course just as quick as we begin to raise that question, we are charged

as surveyors with being interested in a job, that we don't have much to do any way, and we better look up something else. I don't discuss that in any sense in the light of a piece of jobbery, and I don't care who settles it, so that it is eventually settled. It looks to an engineer from a distance that it is a shame if there are people who live in neither the one state nor the other, or to state it a little different, who don't know which state they do live in.

PRESIDENT: Where do they pay taxes?

MR. HODGMAN: In both states, or neither, as the case happens to be.

MR. STEELE: I had supposed that the legislature of last winter paid some attention to the matter, or that a commission was appointed to look into the boundary and prepare for the settlement of the question, but in looking over the proceedings of that body I don't find anything of the kind, so I think it is just where it was, unsettled.

My recommendation is that this Association either appoint a committee independent of myself, or else continue me in the investigation to some future meeting, when I can give them something that is valuable to work upon, which I think could be done by going along the ground or by correspondence with those engineers of ours who are right along the line, who would be pleased to give us all the information needed. We were encouraged to think that the board of supervisors of Hillsdale county would bring it before the legislature, but I am sure that has not been done. I would recommend, therefore, Mr. President, that we have a committee who shall pursue this investigation further.

MR. HODGMAN: I think the matter was laid before the Legislature in 1890 and a resolution passed asking Congress to act on the matter.

MR. SKEELS: I move that Mr. Steele be continued as that committee.

PRESIDENT: Is that motion supported? It is carried. Mr. Steele is continued.

We will listen to the remarks of Mr. Hodgman on the subject of the "Ownership of the Lake Beds," based upon the decision of the Supreme Court of the United States.

MR. HODGMAN: I have but little to add. I have been over the main part of the ground, but I would say that this question was pretty fairly discussed in my paper of last year. Since that paper was written there has been a decision of the Supreme Court of the United States, in which they held that the beds of meandered lakes belonged to the adjacent proprietors in certain cases.

I had intended, if there had been plenty of time, to have read you the decision in full, but that is out of the question now, so I will simply summarize the matter.

The first point that is settled is that the Supreme Court of the United States proposes to follow the lead of the state courts. That is, if the state of Illinois decides that the beds of meandered lakes belong to the adjacent proprietors, all right; if the State of Michigan decides they do not, all right for Michigan, and so on for each state. Each state is a law unto itself. And the question has come up, not only in regard to the ownership, but in regard to the manner of extending boundary lines, whether it should be done according to the common law principles or not. That was one of the questions that came up in the report of the committee on questions.

There is a difference between the common and statute law. Common law comes down from the time when no man's memory runneth to the contrary. It is a growth of usage, and settled by the courts of the different countries, and these decisions have become so permanent that they have been made by the constitution of Michigan a part of the law of the State. The question was raised over in the Dominion whether the laws referred to in my Manual were in force there. "Yes," the crown solicitor replied, "so far as they are applicable to the case."

Under the common law as applied to land bordering on waters, as the water receded the ownership followed it right along, and it didn't follow the direct lines, but went out at some angle in proportion to the shape of the lake.

PRESIDENT: I am in a rather important case at present, and this is the way we propose to present it. Supposing the contour lines to be all drawn, we are going to try to establish the fact that the boundaries of that uncovered lake bed shall be

extended perpendicular to these contour lines. That is practical common law.

MR. HODGMAN: But as Judge Cooley told us, when we are called upon to determine those lines in regard to some of our interior lakes, the surveyor will find himself in the midst of such questions as he never thought of before. But he says, that if the surveyor goes on the ground, and lays down the lines on the ground to the best of his judgment, the chances are, if it comes into court, the court will be governed by his opinion, and it will eventually become the law of the case. Our Supreme Court said that these lands should extend under the water, practically as if there were no water there. I submit to you, that they must beyond question reverse that decision.

PRESIDENT: But the Supreme Court of the United States passed upon this point, the extension of this boundary.

MR. HODGMAN: Yes, they said you must follow the common law doctrine, but they differed. The Supreme Court was divided in this case about as they were in the case of Brown's lessee, vs. Clement. Three judges, Brewer, Gray and Brown, dissented from the opinion of the majority. So, we have two opinions from the court and they don't agree as to what the law in Illinois is, or as to what the common law is. In my judgment the minority are in the right.

If there were time, I haven't a particle of doubt but that the Society would be interested by the reading of these cases in full.

PRESIDENT: Gentlemen, these are matters of great professional interest, and may be matters of great financial interest to us all. In fact, in the case which I referred to in my remarks, I think there are a good many thousands of dollars involved in this very question, and we will endeavor after our very best ability to make some law for you, as definitely as possible, before we get through. We expect to begin in the United States circuit court, and we propose to go on, until we get somewhere.

MR. HODGMAN: Having been called upon to discuss the question of lost corners, I will put what little I have to say on the subject in connection with this discussion. The whole ground has been very thoroughly gone over in my own paper

published in the report of 1881, and Mr. Watkins' paper in the report of 1885. Mr. Watkins' paper leaves little, if anything, more that can be said on the subject. Mr. Kent had a paper on the subject last year, which was not published in the Annual for the reason that we had already published matter covering the whole ground. The substance of it all is to be found in our Manual of Land Surveying, fifth edition, chapter eleven. There is only one rule that can be applied universally without exception to the location of lost corners, and that rule is that the surveyor's whole aim must be to find the point where the corner post of the original survey was actually located, and not where it ought to have been. This is a question of fact to be proved just the same as any other fact, by evidence, and every kind of evidence of whatever name or nature may be used and have its proper and legitimate weight in determining the question. It is unfortunately true that, notwithstanding what has been done by us and by other associations of surveyors, there are still some surveyors left in the country who think they can move the corners of the original survey here and there to suit their own measure, or in case they do not readily find a corner, to plant one of their own where they think it ought to be without regard to where the original corner was located. We all know that such work as that is worse than worthless. The surveyor should exhaust every bit of evidence he can find in regard to the location of a corner before giving it up as finally lost. Look for the bearing trees, for their stumps, for the places where they stood, for the root holes down in the ground, after the trees and stumps have gone. The big roots of an oak or a hickory tree will leave their marks plain in the subsoil for years and years after the trees are gone, and assist in pointing the way to the corner. I have a great deal more faith in old fences as evidence of the location of a section corner or quarter post than I used to have. I have hunted up and restored more than 2,000 government corners, and I find as a rule the fences are good guides to the point where to look for a corner. It is the fences on the half quarter and other interior lines that are more likely to be wrong. Consult the old residents in the vicinity. They may be able to give you valuable pointers. Perhaps they have some private marks to tell them where the

corner is. I have received most valuable aid of this kind. Exhaust all these sources of evidence. Use the pick and spade freely, carefully and intelligently in searching for the corner post. Know what you are looking after, and be sure you know it when you see it. The remains of many a corner stake have been removed and destroyed by persons looking for the corner who did not know the stake when they saw it. When you have found the corner, fix it so it will never get lost again, if it is possible to do so. That is the crowning work of the whole survey. I have no intention of going over the rules for replacing corners which are finally lost. That is sufficiently done elsewhere. What I have already said will give those who need anything of the kind, pointers enough to start them in the right direction in the work.

REPORT OF COMMITTEE ON EXHIBITS.

Mr. L. Beckmann, of Toledo, Ohio, exhibits a five-inch needle, double vernier transit and an eighteen-inch Wye level; also a one hundred-foot Hodgman steel tape.

The transit was on a split leg tripod of good strength and sufficient lightness, in fact the best tripod we have seen. One very small thing is worthy of mention: The opposing nut on the tripod leg bolt is held fast by a set screw. Any surveyor who has had the misfortune to have this nut drop in the last swamp he worked in, will appreciate it.

Your committee consider that the effort to make exceedingly light tripods has been carried too far, especially when a heavy instrument is used with them. A much steadier instrument could be had by reversing the conditions—a *light* transit on a *heavy* tripod.

Mr. B's transit shows fine workmanship in every part, proof enough, we think, that any repairs or designs entrusted to him will be faithfully executed.

The steel tape has an extra foot on the front end. This foot is graduated in tenths, increasing towards the front. This will be found convenient.

The Keuffel & Esser Co., of New York city, exhibit two very fine instruments, a 4½ inch double vernier transit, 10½ inch telescope, and a 20 inch Wye level. The transit exhibited some of their recent improvements, such as bent standards, short telescope axis, hinged shades to verniers, white compass box, and double centers. It was a complete proof that this firm are using their best efforts to improve the transit in every possible way. Your committee observe that the split leg tripod exhibited by this firm is grooved out on the inside to make the legs lighter. This, we think a mistake, as it lacks strength.

The level shown by this firm is of the very best construction. The exhibit made by this firm, your committee consider, is worthy of a more extended mention than we have opportunity of making.

The other exhibits were of such instruments as had been used about the city, such as a Buff & Berger transit and level, a Gurley old style transit, a Heer & Seelig transit, a Stackpole & Bro. transit, and a Heller & Brightly level. These were all good instruments, but were mostly useful by way of comparisons, which these makers have more recently developed by their improvements.

D. & F. E. Skeels show two steel tapes for the purpose of exhibiting their manner of doing up a tape without the trouble of carrying a reel.

Your committee is in favor of the GOSPEL - the Gospel of "Good Roads." If any member does not understand this let him take home a copy of this most commendable new monthly and study it. Not only so, but show it to others.

The "Compass," a monthly journal of much interest to engineers, is also shown, and every number will be found replete with descriptions of improvements and good suggestions.

GEO. E. STEELE,
DORR SKEELS,
ERNEST SELLERS,
Committee.

MISCELLANEOUS DISCUSSIONS.

TIME OF MEETING.

MR. HODGMAN: There doesn't seem to be anything special before the meeting just now, and I would like to get the opinion of the members present, in regard to the time of our meeting. Would it not be a good plan instead of having it the third week in January, to have it the week in which New Years comes? It would not then conflict with the meetings of any of the other surveyors' associations. Last year, if I recollect aright, Michigan, Indiana and Ohio surveyors met at the same date. Mr. Holmes, of Batavia, wrote me to know why we did not arrange our meetings so that he and other instrument makers could attend all the meetings. This year only Michigan and Ohio are in session at the same date.

Another thing is that the Michigan railway association refuses any longer to give this Society any reduced rates except upon terms which it is impossible for us to comply with. But they give reduced rates to everybody during the holidays, and if we should have our convention at that time we could have the benefit of them.

MR. APPLETON: I should be very sorry to see the meetings of the convention so near New Years. How long do these holiday rates extend?

MR. HODGMAN: I don't know, but I guess not over four to six days.

MR. APPLETON: I don't think the attendance would be apt to be any larger - take it the same week New Years is in. Now New Years may come on Tuesday or Wednesday, and I am sure I should feel bound to be at home on New Years, and I think there are others who feel just the same, and that would stop attendance, and I should be very sorry to see it changed to the same week New Years comes, unless New Years should come Saturday or Monday. The question is, however, whether the holiday rates extend so far.

MR. TODD: There is one reason why I should be sorry to see our meeting between Christmas and New Years—because every other year, we are in session at the State capitol and I would like to be there when the legislature is in session. But it may be for the profit of our Society to meet at the time the legislature is in session—we may have something we want to bring before our members, and if we are in session, members who being acquainted with the members from our districts, may possibly bring a force to bear that we could not otherwise.

EXCURSIONS.

PRESIDENT: The matter immediately before you is the excursions. We meet here at two o'clock in this room, when you can take your choice of six different excursions, with the proviso which I will add at the conclusion of my remarks:

To the Soldiers' Home, conducted by Dorr Skeels.

Excursion to Michigan Masonic Home, F. E. Skeels.

Excursion to Grand Rapids Brick Company's grounds, Mr. Ames.

Visit to the furniture factories, conducted by Mr. Christ.

Visit to Street Railway Co.'s electric power house, Mr. Owen.

Inspection of the pavements, and visit to points of interest in the city; the city engineer, Mr. Collar, will be conductor in charge.

There will be an opportunity to inspect the City Railway Company's electric power house. Either one of the first three excursions may be combined with this visit—Soldiers' Home, Masonic Home, Brick Company's grounds—either one of these three may be taken in connection with the visit to the electric power house.

MR. APPLETON: There will be no time, I understand Mr. President, to see anything else, if you take either of these two this afternoon.

PRESIDENT: You must make a choice in the list. I have given you a limit of the choice as well as I am able.

MR. SKEELS: The local committee has seen fit to inflict on the members of this organization something in the shape of a

souvenir, an album with views about the city. They are brought in at this time because some of the members cannot stay with us any longer, and we wish every person connected with the society or with engineering in any way, to appropriate one of these to himself, whether he be visitor or member, presented with the compliments of the city of Grand Rapids. The board of trade has entered into the scheme with us, and present you with copies of their pamphlet.

MR. AMES: I am informed that the Alabastine Company would like to show their works while we are at the Brick Company's works; and also, that in order to combine, as the President mentioned, the first three excursions with the last, it will be necessary to take in some one of the first ones, and we can visit the electric power house when we come back.

PRESIDENT: The presentation of these souvenirs and these publications from the board of trade, will undoubtedly be gratefully received by the members. I have no doubt they will prove not only a sentimental souvenir of Grand Rapids, but a very practical, useful one in some respects, and I would say to the gentlemen who have been so kind as to provide these things for us, that we thank you heartily for them.

AFTER THE EXCURSION.

THE PRESIDENT: One matter which I have neglected. I wish to call your attention to, and beg pardon. I see upon the table here a few books. Here is one, "Notes on Rankine's Civil Engineering," and if any of you think you can read Rankine without notes, you will think differently before you get through. This is one of those books of the utmost practical benefit.

And while I do not wish any man any harm, I wish Prof. Greene was not here, so I could tell you how good a book that is.

Here is a new edition of Mr. Hodgman's book on "Land Surveying" which as you know I have said so many times, is absolutely unique of its kind.

Here is another on "Separate System of Sewerage" by our member, Mr. Pierson, fully as good as the other two, If you want good books, there are three.

There are quite a lot of photographs and matter of that kind for your examination, in which I feel sure you will be interested.

There may be some who have not been here before, and I will say that there are numbers of copies of "The Compass" with which you may supply yourselves and a book, supplied by the Grand Rapids board of trade, views of this city, of which you may have copies as far as they go.

I hope also that you all had as good a time this afternoon as I did, and as much better as you could appreciate. I think we are under many obligations to the local committee and to the engineers of this city, for the exceeding pains and care they have taken in endeavoring to make our stay not only pleasant, but extremely profitable. I have heard more than one person say that they had stored up thoughts and suggestions and ideas and information generally, the whole afternoon through, and I wish it could be conveyed to Mr. Chapman, how fully we appreciate his kindness in lecturing to us by the hour, in giving us information and showing us about the electric light plant. I assure you gentlemen, and I assure him through the local committee, that it is appreciated especially by those of us who have much talking to do, and if he was a little thoughtless about it, he will appreciate it by morning, that he has done a hard day's work.

LEGISLATION.

The Secretary presented and read a letter from W. R. Coats desiring the Society to take steps towards securing the passage of a law requiring hydraulic engineers to pass an examination and receive a certificate of qualification before being permitted to practice in the State:

MR. TODD: There is a matter I would like to speak of as it has been brought up by the communication from Mr. Coats, in regard to the Society taking some action in licensing engineers, municipal and hydraulic. I think there is a crying need that the county surveyor be a licensed man. If there is any man that is subject to wire pullers, it is the county surveyor, and I think if there is any man that may be placed in a position of

responsibility without any consideration of his efficiency whatever, it is the man that is elected county surveyor. We have attempted some legislation in this matter and by the rather discourteous action of the members of the legislature, it was set at naught. I trust some action may be taken in this matter as all of us acquainted with the facts in question, know the importance of having a competent man in that place and know of the frequent incompetency of the incumbents.

MR. HODGMAN: This is a matter in which surveyors and civil engineers all over the country are interested and a line in which many of them have been working for years. I have been written to on the subject by parties in California, Missouri Arkansas, Illinois, and other states, all having the same end in view. They all meet with about the same kind of success so far as I can learn. Nearly every surveyors' association has started out as we did by going through the performance of preparing bills which they have asked their legislatures to enact into laws. But the legislatures have not done it. The bill that we presented to the legislature was treated with great contempt by the committee to whom it was referred and the most galling thing to me about it was that the report of the committee was written by its chairmam—a *county surveyor*, and anything but a competent one at that—to my personal knowledge. The result of it was that we went to work as a society with the principal aim to improve ourselves and to improve the profession. We have done good work in that line. Our work has made better surveyors and better engineers not only all over our State, but all over the United States. Our work has made itself felt all over the United States and Canada and because of what we have done the average county surveyor the country over is a great deal better man than he was before we began our work. And we are not only making better surveyors but we are making better lawyers too. At the same time I confess I do not see any great object in trying to pass laws for licensing surveyors and engineers or any great prospect of it either.

PRESIDENT: I am of the opinion that until the county surveyor has the licensing of the lawyer, it won't be any use to

license the county surveyor. License the county surveyor all you want to, and then license the lawyer.

MR. STEELE: This talk takes me back to the organization of the Society, when we were trying to make a change in the system of election of surveyors, and to get some one who should hold the office of county surveyor who knew how to perform its duties. We could see that men were elected to that office without the slightest knowledge of the business, and there were glaring defects in the laws. We made comparisons with other professions, in which men were obliged to pass examination before practicing. The druggist must be examined before he puts up poisons, but anyone can go out in Michigan and establish lines and make people trouble. He can measure land with a piece of cord, and it is just as legal as work done by the other fellow with a $10 tape.

But when you undertake to get the legislature of Michigan to move in this matter of examination of this officer, or any other surveyor, whether he be elected to the office or not, you will find a good many things in the way. First, who is going to examine him? A board, you say. Another board to be formed. More expense. We can have fish commissioners, and hatch white fish by the million, and the expense is not counted, but when we are talking about making the work of the surveyor more useful and valuable to the owners of property, then we are set at naught. We are trying to turn the cone over onto its apex and make it stand. We can't do it.

Now, I believe this Society did conclude a long time ago that it would allow the poor county surveyor to do just as he had a mind to. They would read up and talk it up and go home and practice what they had learned, and let him do the same. In other words they would improve themselves, and if possible improve him, and every man in the State, without regard to condition or color; try to get him up into a better condition than he was. That is the work of this Society. It is not to put down anybody or deprive anybody of his office, but to help him up. Keep up a big whirlwind here, that will draw in others from all around. Let him see there is something in this work, that we are here for business, not pleasure, and they will be enthused in a little while to join with us.

That is what we want. The more the better. As Mr. Hodgman has said, the condition of every surveyor is far better than it was ten or twelve years ago in this State. His responsibilities are no less, but his opportunities and privileges are greater. What can he do now? By joining this Society, he can get the reports of this and other societies, and gentlemen, I would not take a good many dollars for those folios. I have had them all bound this year, and they make a nice row, and if there is anything I value it is that set of Engineers' Reports. Every time we meet we are making a new report and we are making something we can look at with pride, and I think in that respect, we can invite with a good conscience every man to join us.

Hence, I say I would be opposed to another effort towards working through the legislature at this time, to do away with that office or introduce any system of examination. Not because I don't think it would be good, but because I think it would be an utter waste of time to spend it upon a legislature that would not do anything. They turned their backs to us, and when we, with the utmost respect, sent them our memorial asking to have something done, the committee had the indecency to not even report it. I have never forgotten it, and it will be a long cold day when I sign my name to any other memorial in that line.

MR. TODD: I know that the Michigan Engineering society is making itself felt, even in our legislature. I wish to say that at our last meeting at Lansing, I went to see the senator and representative from our county, and said our society was in convention, and invited them to attend, and they did attend and expressed themselves very much surprised indeed and very much pleased, and further said if there was anything they could do to advance the interests of the society, that was reasonable, they would willingly and gladly do it. Now, I think if every member of this society will take the member of his section in hand, he could manipulate him to good advantage. I think we can bring the matter before them so they can see the equity of it. They are made of the same stuff we are, and I think there is an element of justice even in our legislature.

BUSINESS TRANSACTIONS.

PRESIDENT: Gentlemen, the secretary reminds me that we have a little business to do, and I will trust him to tell you what we have to do. Mr. Secretary you have the deck.

MR. HODGMAN: The officers of this society should make their annual report. Nominations are to be made for officers for the ensuing year, and an amendment to the by-laws, has been submitted to the board of directors which should be acted upon. In order to post the society on what was done at the annual meeting of the board of directors, I will say that the meeting was appointed in accordance with the law, at Lansing, the second Wednesday of October. Only two members of the board of directors were present. They adjourned the meeting to Ann Arbor, where a majority of the board of directors live. I was unable to attend in person, but I received this report of the doings of the board of directors at that meeting:

REPORT.

MICHIGAN ENGINEERING SOCIETY. BOARD OF DIRECTORS. ANNUAL MEETING.

The directors met pursuant to adjournment from Lansing, October 14 to meet in Ann Arbor the week following because of want of a quorum. They met at the residence of Prof. Chas. E. Greene, October 22, 1891, at 7 p. m. Present: Prof. C. E. Greene, Prof. M. E. Cooley, and J. B. Davis directors, and Profs. W. H. Pettee, C. S. Denison, and Mr. Fred Morley members. J. B. Davis was made chairman of the meeting. The secretary, Mr. F. Hodgman, not being able because of ill health to be present, Mr. F. Morley upon being requested by the directors acted as secretary pro tem. for this meeting. From his notes this record is prepared. The members present were invited to take part in the labors of the meeting and did so, much to the aid and gratification of the directors. The first business was canvassing ballots. There were chosen by letter ballot a president, a vice president, a secretary-treasurer, and

three directors. Professors Pettee and Denison were made tellers to assist Professors Greene and Cooley in making the canvass. Two tally sheets were kept.

All the names and votes were canvassed at once. The following is the result: Sixty-three ballots were counted. Two or three could not be counted because it was impossible to discern the voters' choice. One such is preserved showing every name checked. Some others could be counted only in part, for the same reason, the voters' choice could not be discovered from the marks:

For president—Prof. W. F. Durand, 59. Elected.
For vice president—Prof. M. E. Cooley, 37. Elected.
Hon. Geo. E. Steele, 24.
For secretary-treasurer—F. Hodgman, 63. Elected.
For directors—Prof. C. E. Greene, 50. Elected.
Hon. Geo. E. Steele, 33. Elected.
Prof. J. B. Davis, 39. Elected.
Mr. A. J. Teed, 24.
Wm. Appleton, 23.
G. S. Williams, 9.

After full discussion by all present, the directors voted unanimously to hold the next annual convention at Grand Rapids, to begin January 19, at 2 p. m., and continue through the 20th and 21st.

The directors were pleased to receive notice of the following papers for the coming convention and signified their approval by unanimous vote: Sewerage of Dayton, Ohio, Geo. S. Pierson; Hydrographic Surveying, J. H. Forster; Developing Water Bearing Strata for Irrigation or Water Supply, A. L. Reed; Opinion of U. S. Supreme Court on the Ownership of Lake Beds, F. Hodgman; Pneumatic Street Railway Propulsion, S. E. Jarvis; Building Stones, second paper, W. H. Pettee. It was also announced that papers could be expected from Prof. M. E. Cooley, probably on Radiator Tests; Prof. C. S. Denison, probably on Idaho Boundary; Mr. Fred Morley, probably on Survey of Grand river.

Copy of an amendment to by-law six was submitted in writing by F. Hodgman, as required by by-law nine, which was received and filed.

A request was made that Mr. Steele furnish the society with

such information as he is able to relating to the State boundary between Ohio and Michigan, laws, acts, commission work or any matter that he may deem important, that the members may become informed of what has been done relating to this line. Indorsed by the directors. The report of the secretary, Mr. F. Hodgman, was received, read and filed. The report of the treasurer, Mr. F. Hodgman, was received, read and filed. Both reports covered transactions for the preceding year. Bills for actual expenses of the board of directors for this annual meeting for 1891 were allowed and ordered paid.

The secretary was instructed by vote to correspond with the local members relative to making the preliminary arrangements for the coming annual convention at Grand Rapids.

The directors then adjourned.

FRED MORLEY,
Secretary pro tem.

per J. B. DAVIS, *Scrippo.*

The following are the reports made to the board of directors:

ANNUAL REPORT OF THE SECRETARY.

Your secretary would respectfully report the following business transacted by him for the society since the last annual meeting. Immediately after that meeting, arrangements were made and program made out for the annual convention. This was held in Lansing in the pioneer room of the capitol building. The secretary was unable to be present at the convention and the stenographer's report was of so little value that no use could be made of it. For this reason the reports in the Annual both of business transactions and discussions are of the briefest. No report whatever was made of the addresses by Professors Greene and Denison. The contract for printing the Annual was let to the Review & Herald Printing company of Battle Creek. The preparation of the copy was delayed by reason of the want of a suitable report of the proceedings and the publication was further delayed over a month after everything else was in print to secure the advertisements. In

consequence of these delays the annual was not out till July 24, at least two months later than it should have been.

A table of contents of the entire series of annual reports was prepared, but owing to a misunderstanding on the part of the printer was bound separately. I had a sufficient number pasted into the reports for our own members, and have sent out a considerable number of them to surveyors and engineers in the hopes of increasing our membership and the sale of the reports.

I have thus far received only the following exchanges namely: The Technic, the Technograph and the Iowa reports. The report of the Dominion land surveyors has been sent me and now lies in the express office at Climax. The charges are about three times as much as they ought to be and I have refused to take the package until the matter can be adjusted.

There are now on our list 18 members who are two years behind with their dues, 20 who are one year behind and two whose senior membership fee is in arrears. The membership of these two is forfeited according to our by-laws.

The secretary is of the opinion that there should be a by-law by which membership may be forfeited for non-payment of dues or assessments.

F. HODGMAN, *Secretary.*

TREASURER'S REPORT.

RECEIPTS.

Cash on hand Oct. 8, 1890	$73 54
Received from advertisers	264 50
Received from application and membership fees	58 00
Received from dues	208 00
Received from reports sold	3 50
Total	$607 54

EXPENDITURES.

Paid for publishing annuals	$288 11
Paid for postage and envelopes	24 40
Paid for express and freight	5 00

Paid for printing circulars, ballots, envelopes and programs	$13 00
Paid expenses of board of directors	22 77
Paid secretary for salary	100 00
Paid for American Digest and reports	6 25
Cash on hand	148 01
Total	$607 54

The society owes nothing. There is due it from members, $116; from advertisers, $49. A considerable part of this amount will probably never be paid.

F. HODGMAN. *Treasurer.*

SECRETARY'S REPORT TO THE CONVENTION.

Supplementary to these reports the secretary would add that he has sent copies of all the exchange reports received to every member of the society who was not in arrears for dues. The Technograph has been added to our list of exchanges. Missouri seems to have dropped out of our list permanently for some unknown reason. I have not been able to get any communication from the secretary of that society for several years, although I once registered a letter to him to be sure he received it.

Arkansas reports also have failed to show up, for what reason is not known.

Invitations to attend this convention were sent to every surveyor and civil engineer in Michigan whose address I could procure. A large number of blank applications for membership have been sent out some of which have been returned signed.

I would suggest the question whether the interests of the society would not be promoted by changing the annual to a monthly. Suppose that instead of publishing our papers all at once, we take one at a time in its suitable season, send out proofs of the paper and its discussion to selected members of the society for their criticism, and perhaps add matter to the point from our exchanges; all together to make the leading matter

for the number. Add to this personal notes of the work and wants of our members, and condensed engineering news of the month. What do you think of it?

Lastly I would suggest the question, is it not now the time for us to begin a movement for the benefit of the society at the world's fair?

F. HODGMAN, *Secretary.*

SECRETARY: Reports are not sent to any members who are in arrears, and if any member hasn't received his reports he must know one of two things, they were either lost in the mails, or he is in arrears for dues. I have learned of several cases where they have been lost in the mails, and for one or two years, we have sent the exchanges by express.

You have in the proposed amendment to the by-laws means of terminating the membership for non-payment of dues. I will read it here. It was presented to the board of directors, and it is now presented here and you will be asked to act upon it. It is proposed to amend by-law No. 6 so as to read as follows:

6. A member may be reprimanded for not contributing to the papers or discussions of the society, after being officially requested; or for just cause may be expelled from the society by a three-fourths vote of those present, but not without due notice to appear for his defense. Any member who fails to pay his annual dues, or any assessments levied by the society, within two years after the time when such dues or assessments are required to be paid, shall thereby forfeit all his rights as a member, and his membership may be annulled. It shall be the duty of the board of directors at their next annual meeting thereafter, to declare all such memberships annulled, unless at that time the arrearages shall have been paid, and satisfactory reasons given why such action should not be taken. Notice of such required action shall be sent to every member who is two years in arrears, by letter, to be mailed to his last known address, at least one month before the time of the meeting of the board of directors, at which such action is to be taken.

PRESIDENT: Gentlemen, suppose we dispose of these reports first. Suppose we first dispose of the secretary's report, as *secretary*. What will you do with it?

Moved and supported that the report be accepted, and carried unanimously.

The usual disposition I believe of the treasurer's report is to appoint a committee who shall settle with the treasurer. Is that right Mr. Secretary.

MR. HODGMAN: The board of directors usually do that.

PRESIDENT: What shall we do then with the treasurer's report? It has been before the board of directors and received their approval.

It is moved and supported that the treasurer's report be accepted and adopted. Are there any remarks? Hearing none, etc., the report is accepted and adopted.

PROF. COOLEY: I would like to know the assets.

MR. HODGMAN: Cash on hand at the present time, or before this meeting commenced, was $151.01.

PROF. COOLEY: I mean, what we may expect from the members. What are we worth in your judgment?

MR. HODGMAN: I don't understand the full scope of Prof. Cooley's question. We don't owe a cent to anybody.

PROF. COOLEY: What I meant was, how much of that which is still due the society may be still collected. Have we $200 in other words?

MR. HODGMAN: Of the amount reported in October as due, there was about $49.00 for advertisements that has all been collected but $16.00. Six dollars of that was due from G. S. Woolman who has failed, and the rest from the Michigan Car Co. of Detroit. Some portion of the dues from members has also been paid and if it would serve any good purpose I could give the names of those who are in arrears, and the length of time they are in arrears, and the members could judge for themselves. There are a number of members whom we cannot find or hear of, who are a good deal behind and at this time there is standing out $132 due the society from members, but I don't suppose half of it will ever be paid.

PROF. COOLEY: Making about $250 if we can get half of it.

PRESIDENT: You have heard this amendment to the by-laws read, which has been duly submitted to the board of directors, as is required. What shall we do with it?

It is moved by Col. Muenscher and supported that this by-law be adopted.

MR. STEELE: Mr. President, on that question I would like to say a word. I want to understand whether this liberates any member from any obligation he may have, by his simply failing to pay his dues? We are an incorporated society and every member is liable for his share of our debts if we have any. Now if a member sees the pressure is a little too much on him all he has to do is to neglect to pay and be relieved of all responsibility. That won't do. We want at the same time to relieve the Society of responsibility.

MR. HODGMAN: It does just that. Now here are men who haven't been in practical affiliation with the society for years. They don't help us in any way. If we are in debt, we fellows have to carry them. We are paying their share of the expenses right along. We can't reach them, don't know where they are, and I think there should be a way by which those fellows can be dropped out of the society, and all their rights terminated. When that is done, all their responsibility terminates.

PROF. COOLEY: No way of keeping responsibility and sacrificing rights is there?

PRESIDENT: Are there any further remarks? If not, I will put Col. M's motion, that it be adopted. Those in favor, etc.

The by-law is adopted.

PRESIDENT: I think it is proper to make our nominations. We have to nominate president, vice president, secretary and treasurer, and three directors.

I would say that Prof. Durand was notified of his election as president, and immediately sent his resignation, and it was considered the better way, under our by-laws, that the old president should hold over.

Some persons who have just passed in their applications to be voted on will very likely have an opportunity to vote on these nominations, as the vote for members will be decided before the vote for officers, or may be. We nominate here at these conventions such persons as we see fit. These nominations are placed upon letter ballots and sent to every member. We nominate as many and such persons as we choose.

The following nominations were then made:

For president—E. W. Muenscher, J. H. Forster, Geo. L. Wells.

For vice president—Geo. S. Pierson.

For secretary and treasurer—F. Hodgman.

For directors—Dorr Skeels, Wm. Appleton, J. B. Davis, Geo. M. Ames, John K. Yocum, C. S. Denison, Guy H. Carleton.

MR. STEELE: Mr. President, I move that this society send a telegram announcing to Mr. Forster his nomination, and good cheer generally.

THE PRESIDENT: It is moved and supported that a telegram of greeting and congratulation to Mr. Forster, and of good will from the society, be transmitted to him by the secretary.

Hearing no remarks, those in favor of so doing, please say aye, opposed, no. The motion is carried.

MR. STEELE: Is our secretary to have any pay?

PRESIDENT: I will entertain a motion with respect to the secretary's compensation.

MR. STEELE: My motion would be then, that he be compensated the same as last year, $100.

PRESIDENT: It is moved and supported that the secretary be tendered $100 in payment for his services during the past year. Are there any remarks, etc. The chair would wish to say, that you can't pay the secretary. You don't own money nor property enough to do it, and the man who occupies this position, however unworthily, is in a position to know as no other member is likely to, the truth of that remark. Are there any further remarks? Hearing none, those in favor of drawing a check for Mr. Hodgman, for $100, etc. It is a unanimous vote, sir, and you can't escape.

MR. HODGMAN: I have to thank you. I never supposed that Prof. Davis would tell a wrong story. He said you couldn't pay me, but gentlemen, you have paid me, twice over.

PRESIDENT: I am certain that the compensation which Mr. Hodgman most heartily appreciates, is our active interest and co-operation in his endeavors to make this institution a blooming success. This is the kind of pay he likes.

Is there any other matter that you would like to bring up, gentlemen, before we adjourn?

MR. HODGMAN: I move that when we adjourn, we adjourn the convention.

PRESIDENT: Any remarks? Hearing none, etc.

When we adjourn, we will adjourn the convention.

PROF. COOLEY: I haven't had the opportunity, unfortunately for me, of being present as much, during this convention—

PRESIDENT: And unfortunate for us.

PROF. COOLEY: Kind of you, I am sure. But everywhere I have been, and every time I come here, I have felt impressed with the fact, that this local committee have done by us something perhaps that has never been done before. I think they have made us royally welcome, and have placed us in shape to do our work expeditiously and with great satisfaction and profit to all of us, and I should dislike to see this convention adjourn without an expression of thanks to this local committee, for what they have done for us, and I move that this society extend to the local committee their thanks, in as warm and appreciative a manner as possible.

Motion supported.

MR. HODGMAN: No one can feel more than I do, what this committee has done for us. Nothing could be done that has not been done.

PRESIDENT: That is the way I feel about it. It is just as nice as it can be, and I understand all the remarks to support that motion.

MR. STEELE: The effort of this local committee has been the means of giving me great pleasure. I have had the fortune to be conveyed over the city in a fine carriage, much better than I have at home. I have visited some factories here, and what is more than all else, I have been accompanied during all this trip by our worthy president.

PRESIDENT: That was what he meant when he started out, by his misfortune.

Any further remarks gentlemen? Hearing none, etc., unanimously carried. Any further busines?

PROF. COOLEY: I wish to say, what perhaps somebody ought to say, it seems to me that the press of the city is entitled to the thanks and consideration of this body, and also to the city

officers, who have extended to us the courtesy of these accommodations. I should like to make a motion to that effect.

PRESIDENT: Those gentlemen who can read, and have had the opportunity to read the papers (which I have not) can speak about the press in the manner which it deserves; but so far as I could judge by the interest in the meetings, manifested by the representatives of the press, who have communicated with me about the matter, I should say that they were entitled to our thanks decidedly, and I hope Prof. Cooley's motion is supported. Is it?

It is moved and supported that the thanks of this convention be tendered to the press of Grand Rapids for the cordial manner in which they have interested themselves in our proceedings, also to the officers of the city of Grand Rapids, for their courtesy in providing us quarters, making us welcome, and establishing conveniences of various kinds for our convention. Are there any remarks gentlemen? Hearing none, etc., it is unanimously carried.

Is there any further business?

MR. SKEELS: As chairman of the local committee, I wish simply to say that we are glad that you are glad, and we will be still more glad should you at some time in the near future hold another convention in this city. We will throw our present effort in the shade, if you will come.

Applause.

MR. HODGMAN: I have this to say to the gentlemen who have made remarks here, Mr. Bean among others, I should be glad to have them put the points presented on paper, and if there are any who have not furnished me the manuscripts of their papers, I should be glad to have them do so. If we have good luck, I hope to have the Annual out by the first of May. I was delayed, as I said, last year, by several unfortunate things. One was my own illness, and I had to do everything from a sick room. I was unfortunate in getting the advertisements together. If it hadn't been for Mr. Geo. Wells and Mr. Ames we should have fallen short of what we did, but those gentlemen boosted me right out.

But I want to say right here, that it will help a great deal in getting out a creditable report, if we can get lots of adver-

tising patronage, and I want every one of you who can help us in this way, to do it right straight now as soon as you can. I will furnish any one with blanks. Our regular rates are $10 a page, $6 half a page. Some pages for special advertisements more, but these are mostly full.

Mr. COOLEY: Yesterday some gentleman suggested the advisability of printing in our proceedings a list of the membership together with the especial work which they are accustomed to do. That isn't my thought, but on account of that it has occurred to me that I have seen in some of the engineering periodicals, little one or two line advertisements by professional men, giving the man's name and address and the particular service he engages in. Now if there will be twenty-five or thirty who will wish to have published in our proceedings such an advertisement, it would pay, and I for one, would be glad to pay what such an advertisement would be worth, in addition to my annual dues.

Mr. (?) I was thinking of that, only I was going to ask the secretary to make known the least possible living rates for members of the association. The probability is, you could get ten on a page, if not fifteen or twenty.

MR. HODGMAN: Of course the design of this whole business is to get as much money as we can to put into our report. Since I have had the handling of it, I have always aimed in getting out the Annual to keep it entirely within our means and incur no expense but what we had money to pay. Now, if we have more money, there are fine illustrations to be had. We can put in cuts and illustrations which simply stay out if we haven't the money.

By the way, there is one thing I should be extremely glad to do. Through our own Annual, and the publications of the Engineers' Society of the University of Michigan, we have had the portraits of several of our officers. Now it would please me most exceedingly if we could have in our next Annual the portrait of our late president, Mr. Steele.

MR. STEELE: I think it would injure the sale of the book.

MR. SKEELS: I think it would be well to give him notice so he can prepare himself for a sitting.

PRESIDENT: I am in favor of printing Mr. Steele's picture

as president of this society, and I hope we can carry a motion here to have it done. Now Steele, don't make up a face and spoil that picture.

MR. STEELE: When you get right down to solid business gentlemen, I think you might just as well leave it out, and while I would consider it complimentary, I also regard myself as a member of this society who has no such attainment as would make a way for my face in a book that you may get up. And you need not think a moment, because somebody else has been there, that while I have been honored by being your president, I would feel out at all if you never said anything more about it.

MR. SKEELS: Mr. President, I think it would be a good idea to get and publish pictures of the presidents of the association, and follow it down, each retiring president, and all those members who have been presidents, if we haven't got them, why get them, and state the year or years in which they held the office.

PRESIDENT: Very good idea.

PROF. COOLEY: I move that we have the picture of Mr. Steele put in the Annual.

PRESIDENT: It is moved and supported that Mr. Steele's picture be published in the forthcoming annual. Unanimously carried. There is one more matter which is a little serious and that results from the manner in which we record our minutes. Our whole batch of minutes for this whole convention must remain without being approved, by necessity, of course, as the minutes have been taken by a stenographer, it is impossible to have them prepared to present to the convention. The board of directors does not come together until October. We have passed a lot of motions and done a lot of routine business that ought to be tied up someway so that it will stand. We are an incorporated body.

I will entertain a motion to empower the secretary to prepare and publish the proceedings of this convention, subject to revision and correction, as the members may find necessary, before the convention.

MR. STEELE: The only change in your view would be, in my estimation, that he ought to be empowered, wherever he may

think it important, to condense the proceedings. We possibly have a good deal that it would not do to print in the proceedings.

Motion made to that end.

PRESIDENT: It is moved and supported that the secretary be empowered to prepare and publish the minutes of this convention as the official minutes thereof, subject to future revision and reconsideration before the convention at its future sessions, if any member finds it necessary to do so.

Are there any remarks, etc. It is carried.

PROF. COOLEY: Again referring to the fact that I have been so unfortunate as not to be here during the entire session of the convention, I have been informed that our stenographer has been very successful in taking the notes of our meeting. I move that a vote of thanks be rendered her.

PRESIDENT: It is moved and supported that the stenographer receive the thanks of the association for her diligence and success in recording and preserving the minutes of this convention, beside her regular pay.

Any remarks. The motion is carried.

Is there any further business?

It is moved and supported that we do now adjourn.

This convention is adjourned.

MEETING OF BOARD OF DIRECTORS.

A special meeting of the board of directors was held on Thursday, January 21, at which applications for membership were approved and classified as follows:

For senior members H. O. Duerr, James L. Rumsey, F. E. Skeels, J. J. Hubbell, John F. Meighan, Jas. R. Thompson, E. C. Hunt, Henry E. Riggs, Wm. G. Fargo, Henry H. Porter.

For junior members- D. J. Albertson, John Randall, C. B. Chynoweth, Joseph A. Watson, T. O. Williams, F. H. Williams, A. S. Calkins, F. L. Church.

F. HODGMAN,
Secretary.

CONVENTION NOTES.

Mr. Geo. M. Ames, assistant city engineer, exhibited a testing machine owned by the city, and demonstrated the manner of testing cement; making and breaking briquettes.

Mr. Van Amberg, who has charge of repairs on city works, exhibited two machines used in tapping pipes, and explained the manner in which they are used.

Letters were received from members Ripley, Brown, Pelham, Masson, Reed, Pearsons, Bellows, and Bigler, expressing great interest in the work of the convention and a desire to be present.

A letter was received from Wm. M. Whitten, introducing Mr. John F. Meighan of South Bend, who read an interesting paper on the calculation of earth-work and exhibited some tables of his own computation. The paper was received with great interest by the convention but was not furnished for publication.

Mr. Whitten also suggested holding the next convention at South Bend in conjunction with the Indiana engineering society. Owing to the custom of holding alternate conventions at Lansing, it was thought best not to make a change for the next meeting.

A telegram of greeting and good will was sent to the Ohio society of surveyors and civil engineers in session at Columbus, Ohio and a similar response received from them.

Prof. M. E. Cooley exhibited several fine instruments and explained their use among others a Webb adder, a fine Aneroid barometer of great sensitiveness, a planimeter and an indicator for timing the revolutions of a shaft.

The stenographer's notes of Prof. Cooley's remarks were sent him for revision and as they have not been seen by the secretary since, he infers that they are buried under the immense mass of other matters which are so tremendously overworking the genial, kind hearted professor.

Messrs. L. Beckmann of Toledo and Keuffel & Esser of New York had fine exhibits of transits and levels. A number of other instruments owned by the city and by the local members

were on exhibition, making a fine display. A considerable number of copies of the "Compass," a monthly pamphlet published by Messrs, Keuffel & Esser, were distributed among the members. Everybody who uses surveying or draughting instruments ought to take the "Compass." Price $1 per annum.

By request of President Davis a motion was made and adopted making H. A. Collar, city engineer of Grand Rapids, an honorary member of the society.

The local committee "beat the record" and gave the members of the convention a magnificent reception. Nothing that could be done for the comfort or pleasure of the members was left undone, and the convention most heartily appreciated it. Messrs. F. E. Skeels and Geo. M. Ames were prominent in the good work.

Mr. A. L. Reed sent some fine photographs showing details of the construction of irrigation works of which he is engineer and manager in Whittier, California. The water is obtained from wells and carried in a canal which is lined with cement.

A committee consisting of Messrs. Hodgman, Steele, and Cooley were appointed to take measures looking to the benefit of the society during the world's fair at Chicago.

It was understood that some kind of an organization was being effected at Chicago for the benefit of engineers during the fair and that it might be well to look into the matter and perhaps take a part in it. The chairman visited Chicago during the convention of the Illinois surveyors and engineers and while there met Mr. Weston, secretary of the western society of civil engineers and learned from him the condition of the organization at that time. Members of various engineering societies have joined in the movement and effected an organization. It was proposed to expend $15,000 or more in providing for an engineering headquarters in the city—the money to be raised by an assessment equivalent to $2.00 for each member of the various societies concerned in it. No member of these societies to be admitted to the benefits without a ticket from the secretary of his society showing that his $2.00 has been paid. The secretary of the western society evidently has a very poor opinion of the State engineering societies, and the chairman of the committee is of the opinion that the Michigan society

will best maintain its self-respect by doing what it can for its own members and not seeking to join the Chicago organization without an invitation.

LEGAL DECISIONS.

From reports published by the West Publishing Co. of St. Paul, Minn.

1. A corporation platted an addition to a city. The plat showed on the north side a strip 85 feet wide, marked "North." An agent of the company, who was also a director, sold lots fronting on the strip, and told the purchasers that it was a street. Houses were built on either side, and it was used as a street, the city constructing bridges and sluices thereon. *Held* that the evidence was sufficient to sustain a finding that there was a dedication.—*Hitchcock vs. City of Oberlin (Kan.) 26 P. 466.*

2. Where a corporation platted an addition to a city, and the issue is whether a certain strip was dedicated as a street, statements made to that effect by a director of the corporation while selling lots as its agent are competent, but not while selling lots of his own.—*Hitchcock vs. City of Oberlin (Kan.) 26 P. 466.*

3. In 1853 the owner of land in defendant village platted the same into lots and streets, and caused a map thereof to be made. In 1875 one of the lots was conveyed to plaintiff by a deed which described it as bounded by one of the streets in question, which had not then been opened. Plaintiff took possession of the lot, including the street on which it was described as abutting, and cultivated it until 1887, when defendant opened the street. *Held*, that the act of plaintiff in occupying such portion of the street was not a revocation of the dedication, since her deed recognized the street.—*Rathgaber vs. Village of Tonawanda, 13 N. Y. S. 937.*

4. A plat of lands, made by the owner, showing lots, blocks, and streets, but not acknowledged and recorded as required by 2 Terr. Laws, Mich. 577 (1 How. St. c. 32), does not operate

as a statutory dedication of the fee of the streets to the county in trust for the municipality intended to be benefited. 47 N. W. 600 affirmed.—*Village of Grandville vs. Jenison (Mich.) 49 N. W. 544.*

5. In order that a plat showing lots, blocks and streets may operate as a common law dedication of an easement in the street to the public, there must be an acceptance by the public within a reasonable time; and it acquires no rights in a platted street which it failed to use for 34 years, during a part of which time an abutting owner occupied the same by buildings erected thereon, 47 N. W. 600, affirmed.—*Village of Grandville vs. Jenison (Mich.) 49 N. W. 544.*

6. Where the proprietor of land sells lots with reference to a city map showing the land as laid off into streets and blocks, he dedicates the streets as designated thereon to the public, to be opened whenever the public authorities may deem necessary, and when they are opened he cannot recover damages.—*Sherer vs. City of Jasper (Ala.) 9 So. 584.*

7. A deed described the boundary of the land conveyed as a line running a certain course, "about 865 feet, to a point on the shore of Long Island sound; thence running along said shore and sound as the same bend and turn easterly; and thence southerly, to their intersection with" another line specified. The distance named carried the line to low-water mark at a place where the tide ebbs and flows. *Held*, that notwithstanding the rule that only the land to high-water mark is conveyed by a deed naming as a boundary the shore of the sea or other navigable water, this description was sufficient to convey the land to low-water mark.—*Oakes vs. DeLancey, 14 N. Y. S. 294.*

8. The owner of land abutting on Lake Superior platted it, together with the shallows beyond the shore, and sold blocks with reference to the plat. *Held*, that the gradual encroachment of the water on one of the shore blocks, so as to entirely submerge it, did not vest the title thereto in the owner of the adjacent inland block.—*Gilbert vs. Eldridge (Minn.) 49 N. W. 679.*

9. Where the owner of land abutting on Lake Superior plats it, together with the shallows beyond the shore, and conveys an inland block with reference to such plat, the gradual

encroachment of the water until it reaches the block so conveyed does not confer on its owner the riparian right to reclaim and use the submerged blocks and streets.—*Gilbert vs. Eldridge (Minn.) 49 N. W. 679.*

10. The riparian right of the owner of lands on the shore of Lake Superior to reclaim, improve, and occupy the land submerged by shallow water, beyond the shore, may be disassociated from the shore-land by the act of the owner, so that a conveyance by him of the shore-land would not include such riparian rights as incident thereto.—*Gilbert vs. Eldridge (Minn.) 49 N. W. 679.*

11. Where the government conveys land on the bank of a navigable stream without reservation, the land over which the stream flows, as far as the middle line of the stream, and all unsurveyed islands between this line and the bank, pass by the grant, and the riparian owner cannot be divested by a subsequent survey and grant of the islands.—*Butler vs. Grand Rapids & I. R. Co. (Mich.) 48 N. W. 569.*

12. Patents by the general government of public lands bordering on streams are not limited by the meander lines. Following Schurmeier vs. Railroad Co., 10 Minn. 82 (Gil. 59) and 7 Wall. 272.—*St. Paul S. & T. F. R. Co. vs. First Division St. Paul & P. R. Co., 49 N. W. 303, 26 Minn. 31.*

13. Government patents of public lands bordering on streams navigable in fact, issued under the acts of congress providing for the survey and sale of the public lands, do not take to the middle line of the stream, but stop at the stream. Following 7 Wall. 272.—*St. Paul S. & T. F. R. Co. vs. First Division St. Paul & P. R. Co., 49 N. W. 303, 26 Minn. 31.*

14. To determine the division lines between separate holdings in the shallow waters of a navigable bay, of owners of land bordering thereon and located on a cove, from the extreme points of the cove draw lines at right angles to the shore or meander lines meeting at such points, bisect the angles formed by such lines, and extend the bisecting lines to navigable water of, say 15 feet in depth. The points thus reached will be the headlands of the cove. Connect the headlands by a right line. Divide this line into as many equal parts as there are feet in the shore line between the two points of the cove, the shore

line being divided into parts of a foot each. The proprietorship of the land-owners in the inclosed waters is shown by straight lines connecting the corresponding points of division, this rule being based on the assumption that the bisecting lines will reach navigable waters before they intersect.—*Blodgett & Davis Lumber Co. vs. Peters (Mich.) 49 N. W. 917.*

15. The calls in a conveyance of land by a riparian owner were: "Thence N. 8 degrees W. 26 9-10 poles to a stake at Ohio river marked 'I'; thence down said river S. 62 degrees W. 81 6 10 poles to a stake on point at mouth of French creek." *Held*, that the line along the river was low water mark, notwithstanding the facts that before the conveyance actual survey was made fixing the point at I, just over the river bank, and running thence a straight line to point at the mouth of French creek, leaving a space between it and low water mark, and that a diagram representing such surveying and straight line was made, and the further fact that the deed contained the clause that said calls were to be controlled by the diagram.—*Brown Oil Co. vs. Caldwell (W. Va.) 13 S. E. 42.*

16. In an action involving the location of a boundary line between the M. and the A. surveys, it appeared that the M. survey adjoined the A. on the north, and that the disputed line was located in each survey by reference to the south line of the P. survey, which was marked on the ground. The P. survey adjoined the M. on the west. The three surveys were made by the same surveyor. The calls of the A. survey, which was not shown to have been made on the ground, were as follows for the western and northern boundaries. From the S. W. corner "N. 10,017 varas, to a stake in S. B. line of the P. survey; thence E., passing S. E. cor. of said P. survey, and S. W. cor. of the M. survey, 15,500 varas, to a cor. in the prairie; thence S. 1,064 varas, to beginning." The west and south lines of the M. survey were described therein as follows: From N. W. cor. "S 3,685 varas, pass N. E. cor. of P. survey, 13,685 varas, S. E. cor. of same on N. line of A. survey, a corner-stone marked 'X'" giving bearings, etc.; "thence east, with said line, 8,797 varas to beginning." The course "N. 10,017 varas" in the A. survey would carry the N. W. corner of that survey 1,084 varas north of the south line of the P. *Held*, that the south line of the P.

being marked on the ground, and being called for in both the A. and the M. surveys, would control the courses and distances given therein, and the south line of the P., extended east, was the boundary between the M. and the A.—*Montague County vs. Clay County Land & Cattle Co. (Tex.) 15 S. W. 902.*

17. A junior grant on a senior entry called for courses and distances only. It was not surveyed until after the grant, and then the lines were extended beyond the distances called for in the grant, and were marked on the ground. There was no notice given as required by code, *Tenn. § 2020,* where one desires to establish the lines of his land. *Held,* that as against the owner of a senior grant on a junior entry, who had no knowledge of the survey and marking on the lines, the lines must terminate where the distance called for in the grant gave out. —*Bleidorn vs. Pilot Mountain Coal & Min. Co. (Tenn.) 15 S. W. 737.*

18. Plaintiff's deed described the land as "commencing at a point 60 rods west of the northeast corner of section 8, * * * running thence west * * *." The north line of the section did not run due west, as indicated by the true meridian. *Held,* that the presumption is that the line commenced at a point west of the northeast corner of section eight, according to the true meridian, but may be rebutted by extraneous testimony.—*Reed vs. Tacoma Bldg. & Sav. Ass'n (Wash.) 26 P. 252; Clark vs. Same, Id. 253.*

19. An entry contained a call "beginning at the east corner" of a certain other entry. A subsequent call was "so as to include the head-waters of S.," a certain stream. *Held* that, it being necessary to begin at the northeast corner in order to include said head-waters, the first call was made special by the second call.—*Bleidorn vs. Pilot Mountain Coal & Min. Co. (Tenn.) 15 S. W. 737.*

20. By commencing at a point in the first of a series of surveys, and pursuing courses and distances, and occasional marked lines, a certain survey about 20 miles distant would be located about a mile from certain trees called for as a corner in the grant of such survey. There was no other call for a living corner in such grant. These trees were well marked, and were called for as a corner in three other grants made at about the

same time, so that the four grants would corner upon each other. *Held*, that said grant would be located with reference to the call for the trees as a corner.– *Bleidorn vs. Pilot Mountain Coal and Min. Co.* (*Tenn.*) *15 S. W. 737.*

21. In construing a deed describing land by the government survey the court must ascertain the corners of the survey as actually established, and not as they ought to have been established; but the presumption that the deed was intended to convey according to the established corners may be rebutted by evidence that the parties were mistaken as to the location of the government line, and intended to convey a definite tract.—*Squire vs. Greer* (*Wash.*) *26 P. 222.*

22. Plaintiffs' survey described the courses as running south a certain distance to the north boundary line of survey No. 138 and east along the northern boundary of No. 138 and No. 132; but according to the distance recited in the survey the west line would fall short of the north boundary of No. 138, leaving a strip of land between it and the south boundary of plaintiffs' survey. The survey of No. 132, made about the same time as plaintiffs' survey, called for the south boundary of plaintiffs' survey as its northern boundary, and other adjoining surveys made about the same time made it appear that such was the boundary line. *Held*, that the courses and boundaries will prevail as against the distance recited in plaintiffs' survey, making it extend south to the north boundaries of Nos. 138 and 132.– *Wyatt vs. Foster* (*Tex.*) *15 S. W. 679.*

23. When monumental calls in a deed are fully identified, and are sufficient in themselves to show the boundaries, the courses and distances may be entirely disregarded, and this rule is applicable, though it results in an excess of 150 acres in a tract described as containing 240 acres, the excess being mostly covered by water, and of little value when the deed was executed.—*McCullough vs. Absecon Beach Land & Imp. Co.* (*N. J.*) *21 A. 481.*

24. In an action to establish the boundary line between two lots, the evidence was conflicting, and the line was differently located by two surveys. *Held*, that a judgment that the true line was the one marked by a fence, which was supposed to separate the two lots at the time that plaintiff purchased from

defendant, should not be reversed for want of evidence to support it.—*Brooks vs. Allen* (*Tex.*) *16 S. W. 798.*

25. In ejectment to recover land claimed by plaintiff to be included in his surveys of swamp and overflowed land, and by defendant as being included in another survey to him, the county surveyor who made all the original surveys, and his successor, testified that the land was in plaintiff's survey, and there was a natural monument still standing at which the surveys were begun. The surveyor employed by defendant commenced at a stake which defendant told him was the section corner, but about which he knew nothing. *Held*, that the evidence warranted a finding for plaintiff.—*Burdell vs. Taylor* (*Cal.*) *26 P. 1094.*

26. Where adjacent owners are in doubt as to the boundary, and after a survey agree upon a certain line, their agreement is valid, and the line as established by it will be held to be the true one.—*Lery vs. Maddux* (*Tex.*) *16 S. W. 877.*

27. Where an agreement has established a disputed boundary, subsequent conveyances by the parties to the agreement and their privies by the same descriptions as those under which the title was acquired and possession held prior to the agreement will pass the title according to the agreed boundary.—*Smith vs. McCorkle* (*Mo.*) *16 S. W. 602.*

28. Having conveyed certain land to his children, reserving a life interest in himself, the father entered into an agreement establishing a disputed boundary. On his death the children made another agreement establishing the boundary on the opposite side of the land, and therein they referred to the boundary agreed on by their father as the basis from which measurements were to be made. *Held*, that the reference by the children to the line agreed on by the father, and their subsequent conduct in maintaining the line so agreed on, was a ratification of the boundary established by their father.—*Smith vs. McCorkle* (*Mo.*) *16 S. W. 602.*

29. In an action involving the location of the boundary line between the lands of plaintiff and defendant, it appeared that the lands were part of an ancient grant, and were wild, unfenced mountain land. The deeds to the parties referred to the "Livingston line" as the boundary, but neither deed con-

tained sufficient *data* to locate the line. At the time of the conveyance, 30 years before the action was brought, and before any controversy had arisen as to the Livingston line, plaintiff's grantor had a survey and map made of the premises conveyed to plaintiff, and also of an adjoining tract conveyed to one W. The surveyor, since dead, went around plaintiff's parcel, and pointed out to plaintiff the corners and monuments as he (the surveyor) had established or identified them. The map remained in the possession of W. Plaintiff's surveyor testified that he found some of the monuments which the deceased surveyor had established. *Held*, that the map made by the deceased surveyor and the deed to W., and certified copies of older maps of the patent of which the land in question was part, which were on file in the office of the Secretary of State, and on which the Livingston line was marked, were admissible, in the absence of better evidence, as indicating common reputation as to the location of the line.—*Donohue vs. Whitney, 15 N. Y. S. 622.*

30. Where a corner is found on the ground having bearings called for in the patent, which is shown to be the corner of the land as actually surveyed, but there is an inconsistency between this corner with the lines run thence and the calls of the patent, parol evidence is admissible to show that these calls were the result of a mistake, which being shown, the actual survey governs.—*Converse vs. Langshaw (Tex.) 16 S. W. 1031.*

31. In an action for the value of timber cut from plaintiffs' land the complaint alleged that the land was known as the "B. League," and was described in the original grant as commencing at the northwest corner of the E. survey; that such call was a mistake, and was corrected by the original field-notes, which called for the commencement at the northwest corner of the B. survey, which adjoined the E. survey on the north; and that the timber was cut from the boundaries last described. The title referred to the field-notes for a description of the land. *Held*, that such field-notes were properly admitted in evidence to show the location of the land.—*Irvin vs. Bevil (Tex.) 16 S. W. 21.*

32. In ascertaining the actual location of streets and blocks,

the initial point and base line of the survey are not necessarily more controlling, or even as much so, as other ascertained points in the survey.—*Orena vs. City of Santa Barbara (Cal.) 28 P. 268.*

33. An ordinance declaring certain stakes to be the initial points of a survey already made, and attempting to locate lines therein, is void.—*Orena vs. City of Santa Barbara (Cal.) 28 P. 268.*

34. In determining the bounds of a survey a call for another survey definitely located is properly ignored where, if followed, it will necessitate a total disregard of course and distance, and cause the remaining bounds both to conflict with several other surveys and to end so far from the starting point as to exclude about 1,000 acres from the survey.—*Cregg vs. Hill (Tex. Sup.) 17 S. W. 838.*

35. Where the question is as to the true location of a government corner, and whether a certain mound, pits and stake, testified to by witnesses, were the original marks of such corner, it is not error to admit evidence to show that such marks were years before, when they were very plain and distinct, generally regarded and recognized as indicating the original government corner; and to that end it may be shown that permanent improvements, as lines of trees, roads, buildings, public and private, were, when such indications were plain and visible, located with reference thereto as the true government corner, by persons who had no other interest than to locate them correctly.—*Arneson vs. Spawn (S. D.) 49 N. W. 1066.*

36. Comp. Laws Dak. § 689, which provides that a survey made by the county surveyor "shall be held as presumptively correct," applies only to a survey made, authenticated, and recorded as provided by the statute; and parol evidence by the surveyor as to where and how he established a government corner does not take the place of his official report, nor support the same presumption.—*Arneson vs. Spawn (S. D.) 49 N. W. 1066.*

37. In an action involving the boundary line of land, the original corners, as established by the government surveyors, if they can be found, or the places where they were originally so established can be definitely determined, must control, with-

out regard to whether they were located with mathematical correctness or not.—*Arneson vs. Spawn (S. D.) 49 N. W. 1066.*

38. The fact that a purchaser of land, holding and claiming ownership thereof, has not yet paid the consideration therefor, does not invalidate a parol agreement made by him with an adjoining land-owner fixing the boundaries between their land. —*Cavanaugh vs. Jackson (Cal.) 27 P. 931.*

39. Surveys Nos. 323 and 324 were patented to plaintiff's husband. In 1870 his agent employed one B. to survey No. 324, and one W. had him survey No. 323. B. did not find the corners called for in the field-notes, and located the lines by their relation to the lines of other surveys as shown by a land-office plat. Soon afterwards W. purchased No. 323 by the description given in the patent. In 1879 the bearing trees called for by the field-notes were discovered, and the lines were run in accordance therewith. The survey of 1870 gives the land in dispute to the intervenor, who claims under W., and that of 1879 gives it to No. 324. *Held*, that a verdict sustaining the survey of 1879 should not be disturbed.—*Koenigheim vs. Sherwood (Tex.) 16 S. W. 23.*

40. Surveys Nos. 323 and 324 were patented to plaintiff's husband. In 1870 his agent employed one B. to survey No. 324, and one W. had him survey No. 323. B. did not find the corners called for in the field-notes, and located the lines by their relation to the lines of other surveys as shown by a land-office plat. Soon afterwards W. purchased No. 323 by the description given in the patent. When he made the survey in 1870, B. divided No. 324 into lots. The plaintiff's husband conveyed two of the lots "as laid off by B.," and after the conveyance by W. to the intervenor the plaintiff, as her husband's devisee, conveyed other lots by reference to B.'s survey. W. and the intervenor have held possession of the strip in dispute since the purchase by W. *Held*, that it was for the jury to say whether she was bound by acquiescence in the line located by B., and a verdict in her favor should not be disturbed.—*Koenigheim vs. Sherwood (Tex.) 16 S. W. 23.*

41. It is competent to establish the lines and courses of a tract of land by showing where the surveyor actually ran when making the boundaries at the instance of the parties to the

conveyance, and with a view to its execution.—*Euliss vs. McAdams* (*N. C.*) *13 S. E. 162.*

42. A junior deed is not admissible as evidence to locate the corner of land conveyed by an older deed.—*Euliss vs. McAdams* (*N. C.*) *13 S. E. 162.*

43. Where a surveyor establishes two initial points on the ground itself, and from these the remaining surveys are plotted in on a map, and in the plot calls are made for a river, the true course of which the surveyor has mistaken, the surveys must be run out as plotted, the calls for the river yielding to course and distance.—*New York & T. Land Co. vs. Thompson* (*Tex. Sup.*) *17 S. W. 920.*

44. Where a deed describes the land as bounded as follows: "Commencing on the road" at a certain point; "thence west ten rods; thence south four rods; thence east ten rods; thence north on the road to the place of beginning." the presumption is that the measurements commenced from the side of the road, instead of the center; but the acts of the parties, contemporaneous with the delivery of the deed, in fixing the monuments and fencing the lot as if the measurements commenced from the center of the road, are admissible in evidence upon the question of the construction to be given the deed.—*Dodd vs. Witt 29 N. E. 475. 139 Mass. 63.*

45. Where it is uncertain whether a call in a deed for a line parallel to the boundary of a certain survey means a line parallel to the main line of such survey, or to a short, irregular part thereof, the question is for the jury.—*Lecomte vs. Toudouze* (*Tex. Sup.*) *17 S. W. 1047.*

46. A contract for the sale of land described the property as the N. ½ of the N. ½ of a certain lot. An informal memorandum, signed by the parties before the contract was drawn, described the land as above, and also as "the C. & G. block." The evidence showed that the lot was 150 feet long, and that the north 40 feet of it constituted the C. & G. block. *Held*, that the contract called for the north 40 feet of the lot, as the block was a fixed and permanent monument, which would control the other description.—*Lyman vs. Gedney, 29 N. E. 282, 114 Ill. 388.*

47. A surveyor, hired by a city to make a survey and divis-

ion into blocks and streets of its lands, the streets to be 60 feet wide, and the blocks 150 yards square, and the corners of the squares to be marked by stakes, made the survey according to contract, and actually located the blocks and streets, marking each block by a stake, many of which remained for several years. His return of survey was merely that the survey was made, as directed in the contract, but contained no field-notes, and made no mention of any initial point or base line. Thereafter the city had made, and adopted as official, maps which purported to show said survey. And certain streets as so surveyed and mapped were declared open. The city then deeded a certain number of square feet, describing them as in a certain corner of one of said blocks, and bounded by two of said streets. *Held*, that the lot was bounded by the streets as actually located by the surveyor, and that, the stakes showing the location of the block and street lines having been lost, and there being no evidence of the precise point where they had been placed, evidence of the boundaries of the street as actually opened and used was material.—*Orena vs. City of Santa Barbara (Cal.) 28 P. 268.*

48. The fact that the grantee of the land inclosed his full quantity of land within the block, taking as the street line the boundary as actually opened, and that he acquiesced in this line for many years before putting out his fence into the street as actually used, is evidence of the correctness of the boundary as opened.—*Orena vs. City of Santa Barbara (Cal.) 28 P. 268.*

49. The acquiescence or admission of the owner of land, made under a mistake as to his rights, will neither estop nor prejudice him from subsequently enlarging his possession to the limits of his deed, provided no actual adversary possession has intervened to defeat his title.—*White vs. Ward (W. Va.) 14 S. E. 22.*

50. In trespass to try title between adjoining land-owners, defendant testified that he had settled the disputed boundary line by oral agreement with plaintiff and her husband, and that a bend in the line was to be made to allow plaintiff to retain certain improvements she had made. The county surveyor testified that, at the request of defendant and plaintiff's husband, who stated that they had settled the disputed line, he

surveyed the line under their directions so as to leave plaintiff her improvements, and that they expressed their satisfaction with the line as run. The surveyor was corroborated by three witnesses as to the agreed line. The parties immediately erected a fence on the line, and each held possession up to the fence till the beginning of suit, 18 months afterwards. *Held*, that the parties had established the boundary by oral agreement.—*Lecomte vs. Toudouze* (*Tex. Sup.*) *17 S. W. 1047.*

51. On appeal from a survey of a disputed boundary line, taken three years after the making of the survey, it may be shown that by mutual agreement the survey was abandoned and new boundaries established; that the parties moved their fences to the new line; and that each continued to hold possession up to such line until the trial.—*Horton vs. Brown* (*Ind. Sup.*) *29 N. E. 414.*

52. A large tract of land was laid off, for the convenience of selling, into smaller tracts, by running a base line and laying down the division lines by protraction, which division lines were never actually surveyed. The coterminous owners of two of said tracts attempted to survey and mark the true division line between their lots, and in so doing a mistake was made in running said line so as to include a large portion of one of said lots within the other, there being no dispute as to the true boundary. *Held* that, when said mistake was discovered, neither of the parties, nor their grantees, were estopped to claim his rights, nor could it be construed as a license from the one party to the other to cut timber between the true line and the mistaken boundary.—*Hatfield vs. Workman* (*W. Va.*) *14 S. E. 153.*

53. An agreement between adjoining owners establishing their dividing line is not void though the parties were mistaken in believing that the agreed line approximated the real line.—*Lecomte vs. Toudouze* (*Tex. Sup.*) *17 S. W. 1047.*

54. A conveyance of riparian lands by metes and bounds, which on the river side are substantially coincident with high-water mark, carries, under Code, *Va.* § *1339*, all the right of the grantor to the strip lying between high and low water mark.—*McDonald vs. Whitehurst* (*Cir. Ct.*) *47 F. 757.*

55. The owners of a mill dam and pond conveyed land on the west side thereof, describing the boundaries in the deed as "running easterly * * * to low water mark, on the west side of Fox river, [the mill pond]; thence running northerly along the low water mark on the said westerly side of Fox river," etc. *Held*, that the grantees took only to low water mark, and not to the center thread of the river.—*Allen vs. Weber (Wis.) 50 N. W. 514.*

56. The fact that such deed reserved to the grantors the right to flow the strip conveyed does not indicate an intention to convey to the center of the pond, since the right reserved might have been to flow the land down to the low water mark of the pond only. *Allen vs. Weber (Wis.) 50 N. W. 514.*

57. Where the grantees from owners of a mill-dam and pond of land on one side thereof, have acquired title only to low water mark of the stream; a subsequent act of the legislature, declaring the stream navigable, cannot affect the rights of the owners in the pond, or vest such grantees with title to the middle thread of the stream.—*Allen vs. Weber (Wis.) 50 N. W. 514.*

58. Where the last call in a grant of land is "125 poles, to the beginning." and the beginning point is established, the line must extend to or stop at it, regardless of distance.—*Cowles vs. Reavis (N. C.) 13 S. E. 930.*

59. Where the lines which inclose four surveys in the interior of a block of surveys are marked on the ground by interior lines of the block and by lines peculiar to the four surveys, the lines which separate them from each other cannot be located by marks on the lines which inclose the block.—*Ferguson vs. Bloom (Pa. Sup.) 23 A. 49.*

60. The returns of survey gave four interior tracts of a block of surveys a common corner, and made two of them adjoin the other two along the entire western sides of the latter. The returns of survey also showed the south lines of the northern pair to be parallel with their north lines, and both the north and the south lines to be continuous; but the work on the ground showed that their north lines did not form a continuous line, but that one of the tracts extend north a half mile further than the other, with well marked lines all the way around the projecting part, which were peculiar to that tract, and not com-

mon to or in any way affecting the location of the other tracts. By means of the marks of the original survey on the ground, and the presumption that lines returned as parallel are so in fact, the four tracts could be located as separate surveys, with rectangular figures, without disregarding the returns of survey, except as to the tracts having a common corner, and as to their adjoining along their entire breadth, which latter provision of the returns was shown by the work on the ground to be a mistake and impossibility. Treating the four tracts as constituting a subordinate or interior block, carved out of the larger one, and entitled to the application of the same principles for the adjustment of its interior lines, and drawing a line between the points in the exterior lines marking the divisions between the northern and southern pairs, the four tracts are given a common corner, but the provisions that the sides be parallel and the tracts rectangular are disregarded. *Held*, that the four tracts should be located as individual surveys, and not as forming a block.—*Ferguson vs. Bloom* (*Pa. Sup.*) *23 A. 49.*

61. Three adjoining lots, fronting on the south, one of which was on the southwest corner of a square, were of a number that had been carved out of a tract of land of which three subdivisions had been made for the grantees of two portions thereof and the owner of the residue, respectively, by the same surveyor at short intevals of time. The owner of the east lot built his fence to conform to others in the rear, that had been erected at random, and the owner of the middle one took possession of the quantity of land called for by her deed, west of said fence. In subdividing said land a stone had been placed in the eastern line of the original tract, and it was found by running a line west therefrom for the distance called for by the several plats that the west fences of the corner and east lots were 11 feet too far west, as well as those of the lots in the rear, which were of the same width. *Held*, that the owner of the middle lot was in possession of 11 feet of land belonging to the owner of the corner lot.—*Quick vs. Butler* (*Ill. Sup.*) *28 N. E. 926.*

62. Where each of two coterminous proprietors recognizes the ownership of the other, and that the tract of each is bounded by that of the other, the ascertainment of the true line between

them fixes the extent of their respective tracts.—*Phillips vs. O'Neal (Ga.) 13 S. E. 819.*

63. Where a division line between two tracts of land owned by different persons has been extended in the wrong place, and then expressly agreed that it should be the line between them or accepted and acquiesced in as the dividing line from 1875 to 1883, it becomes their established division line.—*Harrell vs. Houston, 17 S. W. 731, 66 Tex. 278.*

64. In ejectment to recover a strip of land, part of one of three adjoining lots, the owner of the middle lot testified that when she went to look at it before buying it she met a man, who said that a fence which was not on the line was the eastern boundary, and that he stepped the land off from it. There was no evidence as to who he was, that he knew of any dispute, and had authority to settle it, or that, when the owner of the adjoining lot acquired his title from the same grantor, he had any notice of an agreement that said fence was to be the eastern boundary of the middle lot; and when a dispute arose as to the western boundary thereof its owner mentioned no such agreement, but said she would move her western fence, if it were insisted upon. *Held*, in ejectment, that said facts did not constitute an estoppel *in pais.—Quick vs. Butler (Ill. Sup.) 28 N. E. 926.*

65. Plaintiff in an action to determine a boundary, traced title from a certain person to himself for the whole of a certain lot. Defendant gave in evidence a deed from the same person for the western end of the lot. The boundary was described with reference to several monuments. The courses and distances named were inconsistent, and showed an evident mistake. *Held*, that the burden was upon the defendant, and that, unless one or more of the monuments could be fixed, so as to establish the boundary within plaintiff's lot, plaintiff was entitled to recover.—*Henry vs. Huff (Pa. Sup.) 22 A. 1046.*

66. In trespass to try title, brought by the owner of the balance of the block to recover a strip of land in excess of the five acres conveyed to the grantees in a deed, a surveyor who made a survey of the land may testify as to his location of the boundaries of the five acres, though the survey was not made under order of court.—*Henry vs. Whitaker (Tex. Sup.) 17 S. W. 509.*

67. In an action involving the location of a boundary line between adjoining land owners, both parties claimed through the same grantor. On the trial, a bond of title to the ancestor of defendant was exhibited, which contained reservations of certain tracts previously sold to parties specifically named, but no mention was made of plaintiff. Plaintiff claimed that a bond had been made to him which was lost or mislaid. The testimony as to possession was conflicting, both parties claiming to have exercised ownership over the land in issue by occasional use of the timber thereon. Defendant showed that his ancestor had built a cabin on the land, which had been occupied by tenants who held under him. In a previous controversy plaintiff sued defendant for forcibly entering upon this land, and a verdict was rendered for defendant. *Held*, that a judgment for defendant was sustained by the evidence.- *Jones vs. McCrackin (Ky.) 17 S. W. 626.*

68. In ejectment the question was as to the location of a section corner. Plaintiff's evidence tended to show a government mound erected at the point claimed by him, and a survey by H. made in 1845. Defendant's witnesses testified that they lived in the immediate neighborhood in 1842, at which time the government corner was lost, the monument having been rooted up by hogs. Defendant introduced proof of a survey made by L. in 1851, by starting from a known government corner half a mile north of the point in dispute. *Held*, that a verdict for defendant was not against the weight of the evidence. *Green vs. Mumper (Ill. Sup.) 28 N. E. 1075.*

69. The United States interior department, by a circular issued in March, 1883, gives the following method for the restoration of lost or obliterated corners of government surveys on base and correction lines: "Run a right line between the nearest existing corners on such line, whether base or correction line, which corners must, however, be fully identified, and at the point proportionate to the distance given in the field-notes of the original survey establish a new corner. This point should be verified by measurements to the nearest known corners north or south of the base or correction line, or both." *Held*, that the corner so established is not conclusive, and is not to be preferred to a survey between two fully identified

corners, with which, upon actual measurements, it fails to verify. – *Hess vs. Meyer* (*Mich.*) *50 N. W. 290.*

70. If the beginning corner in the description of a tract of land has been destroyed, it is proper, in order to ascertain the true boundary, to survey the land by beginning at any known corner or point from which the boundaries may be located. *Cowles vs. Reavis* (*N. C.*) *13 S. E. 930.*

71. Where a patent calls for unmarked lines of surrounding surveys, the position of which can be accurately ascertained, and there is no evidence as to how the survey was actually made, such unmarked lines will prevail over courses and distances, in case of a conflict.—*Maddox vs. Turner* (*Tex.*) *15 S. W. 237.*

72. Where adjoining land-owners have settled the boundary line between their respective tracts with full knowledge as to the true boundary, and have both occupied up to the line as established for more than 21 years, they are estopped from disputing the accuracy of the line as established.—*Sheetz vs. Sweeney* (*Ill.*) *26 N. E. 648.*

73. Allegations that the true location of a certain lot was not well defined and known, and that various surveys had left it uncertain, are sufficient to sustain an agreement fixing the boundary line.—*Harne vs. Smith* (*Tex.*) *15 S. W. 240.*

74. Such an agreement is valid and binding on the parties and their vendees, though they were both mistaken as to the true location of the line.—*Harne vs. Smith* (*Tex.*) *15 S. W. 240.*

75. The description in a deed began: "The south half and the east half of the northeast quarter of section nine," described several subdivisions and concluded: "Containing, in all, 540 acres." If the first clause was interpreted to mean the south half of the northeast quarter and the east half thereof, the effect would be to duplicate the description of one "forty," while to construe it as meaning the south half of section nine and the east half of the northeast quarter thereof would avoid any duplication, and conform the description to call for quantity. *Held* that, under the rule that the call for quantity may be resorted to to make that certain which would otherwise be

uncertain, the latter interpretation should be adopted.—*Davis vs. Hess (Mo.) 15 S. W. 324.*

76. The description in a deed was, "a certain tract or parcel of land begins at a pine on R. line, thence running K. S. line, thence binding on L. S. line, thence running the T. L. line, then to the first station, including twenty-five acres, be the same more or less." *Held*, that the description is not void for uncertainty, since the boundaries pointed out may be established by extrinsic evidence.—*Allen vs. Sallinger (N. C.) 12 S. E. 896.*

77. Where land is known both as the "Geo. P. Digg's Survey" and the "J. P. Digg's Survey," and there is but one Digg's survey in the county, the variance in a deed between "Geo. P." and "J. P." does not amount to a misdescription.—*Burchard vs. Record (Tex. Sup.) 17 S. W. 241.*

78. When an authenticated plat of land is referred to in a deed conveying a portion of the tract, it becomes as much a portion of the deed as if fully incorporated in it.—*Whitehead vs. Ragan (Mo. Sup.) 17 S. W. 307.*

79. Where a deed conveys lots according to a certain plat, the fact that the plat is invalid does not affect the deed.—*Young vs. Cosgrove (Iowa) 49 N. W. 1040.*

80. A land owner having sold 22.29 acres of the southeasterly portion of a certain quarter section, conveyed to another person "the east one hundred acres [of the quarter section] commencing on the west bank of the F. river, and running back to the westward far enough so as to contain one hundred acres, and so as to comprise the east one hundred acres [of the quarter section] excepting therefrom a small piece of land" previously sold. *Held*, that the deed conveyed 77.71 acres. McKee, J., dissenting.—*Cox vs. Hayes, 27 P. 785, 64 Cal. 32.*

81. A deed conveying lots 1, 2, 3, and 4, in a block, they being all the numbered lots in the block, does not pass title to any part of a strip of land included in said block, but not numbered as a lot.—*Young vs. Cosgrove (Iowa) 49 N. W. 1040.*

82. Plaintiff purchased a lot fronting on the south side of a street in a village from a corporation owning the street, and the lands on either side thereof. Defendant dug a ditch in front

of defendant's lot, between the sidewalk and the middle of the street, of such depth that it cut off the veins of water supplying plaintiff's well in front of this lot. *Held*, in an action to recover damages for defendant's alleged trespass in digging the ditch that the question whether or not the plaintiff's lot extended to the middle of the street was one dependent upon the interest of the parties to plaintiff's deed; and that, plaintiff's deed having described his lot as beginning at a point on the southerly line of the street and running thence along the south line of that street to a certain point, the intent of the grantor was to exclude any portion of the street from the grant.—*Dexter vs. Riverside & Oswego Mills 15 N. Y. S. 374.*

83. A deed to premises bounded on one side by Long Island sound, which described one of the boundary lines as running north to a point on the sound, and "thence running along said shore and sound as the same bend and turn easterly, and thence southerly," to another intersecting boundary line, conveys the space on the shore of the sound between high and low-water mark, and the purchaser who bought by the acre is not entitled to have the purchase price per acre of the premises abated to the extent of that space, as for a deficiency in the acreage. Affirming *14 N. Y. S. 294*—*Oakes vs. DeLancey 15 N. Y. S. 561.*

84. Where a deed describes the land by metes and bounds, and then gives a general description of it as being "all of the * * * survey, except 140 acres belonging to" a certain estate, the particular description must control, and only the land contained within the described metes and bounds passes.—*Cullers vs. Platt (Tex.) 16 S. W. 1003.*

85. A deed of land, describing it by boundaries, and as containing a designated quantity, is not a conveyance within fixed limits, so as to give the donee title to land in excess of the quantity named, where one of the boundaries is given as the donor's own land, and no limit is fixed as to where such boundary is to commence. *Derouen vs. Davidson (La.) 10 So. 7.*

86. A grantor conveyed "lot 1, block 2, town of Concho, M's addition to San Angelo, said lot being 60 feet front by 120 feet deep." Afterwards he conveyed to the same grantee "lot 2, block 2," "said lot being 60 feet front by 120 feet deep." The grantor owned the whole block at the time of these conveyances.

The addition had been laid out by him, and the plat on file in the county clerk's office divided block 2 into lots 26 feet wide by 120 feet deep. *Held*, that in the absence of evidence indicating a contrary intention, the word describing the width of the lots must be rejected as *falsa demonstratio*.—*Arambula vs. Sullivan* (*Tex.*) *16 S. W. 436.*

87. A deed conveying a portion of a block of land described the boundaries as "beginning with the southeast corner of the block; thence west with the south boundary line of said block —— varas, to a stake;" and then gave the remaining boundaries by courses and distance, "so as to contain five acres of land off the east side of the block." *Held*, that the deed limited the quantity of land intended to be conveyed to five acres, and that the length of the first line called for in the deed was not specified because it was intended for that line to be only long enough, when considered with the other calls in the deed, to make an area of five acres.—*Henry vs. Whitaker* (*Tex. Sup.*) *17 S. W. 509.*

88. S. and G., owning a lot in common, divided it between them, and their portions, by mesne conveyances, became vested in plaintiff and defendant, respectively, through an intermediate grantee of both portions. The deed of S.'s portion down to plaintiff described the tract as containing 93 acres, more or less, and the deeds from G. down to defendant described his portion as containing 100 acres, more or less. The land in dispute was a tract midway of the lot which each claimed to be included in his portion. *Held*, that if plaintiff first purchased from such grantee with reference to a boundary established by S. and G., he would be entitled to take up to that boundary only, whether the tract so determined contained the number of acres called for by his deed or not; but, if he purchased by an imaginary boundary, he would be entitled to 93 acres, though it might leave defendant, who purchased after him, less than the number of acres called for by his deed.—*Adams vs. Powell* (*Ga.*) *13 S. E. 280.*

89. S. and G., owning a lot in common, divided it between them, and their portions, by mesne conveyances, became vested in plaintiff and defendant, respectively, through an intermediate grantee of both portions. The deeds of S.'s portion down

to plaintiff described the tract as containing 93 acres, more or less, and the deeds from G. down to defendant described his portion as containing 100 acres, more or less. The land in dispute was a tract midway of the lot which each claimed to be included in his portion. The evidence tended to show that a boundary line had been established between S. and G., which was recognized by subsequent purchasers. *Held*, that it was error to charge that, if defendant had 100 acres without taking in the tract in dispute, and plaintiff did not have 93 acres without including it, plaintiff should recover the tract; since if S. and G. had established a boundary line, and defendant had purchased his tract with reference to it, he would be entitled to hold it, though it contained more than 100 acres.—*Adams vs. Powell (Ga.) 13 S. E. 280.*

90. In an action of trespass defendant railroad company put in evidence a location, the validity of which was not disputed, of land which was described as adjoining the land of plaintiff's predecessor in title. Defendant, after filing the location, accepted a deed from plaintiff's predecessor, describing the land conveyed as the land taken by the location, which description did not include the land in dispute; but at the date of the location defendant did not admit, nor did plaintiff's predecessor claim, that the latter had title to the premises. It also appeared that plaintiff's predecessor gave defendant a license to use land, which license would have been useless unless defendant owned the land in question. *Held*, that defendant was not estopped to claim that the land in question was covered by the location.—*Cunningham vs. Boston & A. R. Co. (Mass.) 27 N. E. 660.*

91. The owner of a survey conveyed a certain amount from the east side of the tract, the west line being marked on the ground where defendant claims, and the land was subsequently deeded to M. Plaintiff acquired title to the west side of the tract, and caused a survey to be made, the east line of which was run and marked on the ground 18 rods east of M.'s west line, thus including the strip of M.'s land which is in dispute, and the survey was returned to the land department, and a patent issued. Neither the survey nor the patent called for *any* marked line, but merely called for M.'s land as adjoining *on the* east. M. also caused a survey of his tract by the same

surveyor, and received a patent, but neither the survey nor the patent referred to the line established in plaintiff's survey, but merely called for plaintiff's land as adjoining on the west. M.'s land was, after mesne conveyances, deeded to defendant by deed describing the land as the same previously conveyed to M. There was no evidence that M. agreed to the line as established by plaintiff's survey, nor that M.'s survey and patent adopted it. *Held*, that defendant was in privity with M., and has title to the tract according to the line as established before plaintiff's survey.—*Waters vs. Starr (Pa.) 21 A. 865.*

92. Defendant and plaintiff's predecessor in title took a conveyance of the north half of certain lots, the south half of which had been conveyed to one R. There was a fence supposed to be R.'s north boundary. On partition the south 58½ feet of the land was measured north from the fence and conveyed to plaintiff's predecessor, a notch being cut to show the division line. It was afterwards found that R.'s true boundary was 3.3 feet north of the fence, and plaintiff sued to recover a strip of that width north of the division line as fixed by the notch. The deed of partition and subsequent deeds of plaintiff's lot called for R.'s land, and not the fence, as its southern boundary, and described the lot as 58½ feet wide. *Held*, that testimony was not admissible to affect or vary the boundaries as fixed by the deed, and that the location of the division line in partition was not binding, if by mutual mistake the parties took R.'s fence as the true north boundary of his lands.—*Davis vs. Russell (Pa.) 21 A. 870.*

93. Where the original survey and field-notes of a township show all the sections full, but, after all the natural monuments in the two northern tiers of sections have been lost, it appears that there is a shortage somewhere within those two tiers, such shortage will be apportioned between the two tiers, and not imposed wholly on the northern tier, though the survey was made by beginning at the southeast corner of the township, and working north. *James vs. Drew (Miss.) 9 So. 293.*

94. On a question of boundary between adjoining lands, evidence is admissible that a former owner of part of the land on one side of the disputed line, since deceased, while upon the land, negotiating a sale of it, pointed out the location of the line and the landmarks upon it; it not appearing that he

had any interest to locate the line differently from its true position.—*Royal vs. Chandler (Me.) 21 A. 842.*

95. Upon conflicting evidence as to whether acts and declarations of a former owner of land, offered as proof of the boundary thereof, were made before or after he conveyed the land, the question is to be determined by the judge, in his discretion.—*Royal vs. Chandler (Me.) 21 A. 842.*

96. In 1844 a land owner granted lands, bounding them on the south by the center of the "state road," and on the east by a north and south line far enough east to include 40 acres. Subsequently he granted other lands on the east of this tract. On a question as to the location of the common boundary, it appeared that in 1844 there existed a recorded plat of a state road, but the road existing at the time of the trial did not correspond therewith. On the evidence it was doubtful whether any state road had been opened in 1844. *Held*, that the plat was properly admitted, since, if no road was open, the description must refer to it.—*Atwood vs. Canrike (Mich.) 48 N. W. 950.*

97. In an action involving the location of the dividing line between the lands of plaintiff and one M. it appeared that a continuous straight line formed the north boundary of both tracts and the south boundary of the land of one E. E. testified that he had divided the division fence with plaintiff and M., and that for 50 years he had begun at a white oak, which plaintiff claimed as his northeast corner, and built the east half of the fence between the land of himself and plaintiff, and the west half of the fence between the land of himself and M. On cross-examination it appeared E. built half of the fence between his land and that of plaintiff and M., and that the part so built by him was on both sides of the oak, but that neither party had ever spoken of the oak as the point of division. *Held*, that the testimony of E. should have been stricken out on defendants' motion.—*Ostrander vs. Washburn, 14 N. Y. S. 584.*

98. On a question whether defendants had maintained adverse possession for 15 years up to a certain fence, it was error to admit evidence that it was commonly understood in the neighborhood that the fence was not on the true line.—*Atwood vs. Canrike (Mich.) 48 N. W. 950.*

HON. GEO. E. STEELE.

BY FRANK HAMILTON, OF TRAVERSE CITY.

Geo. E. Steele, of Traverse City, Michigan, was born October 23, 1842, in Andover, Ashtabula county, Ohio. His ancestors on his father's side he follows back nine generations to the year 1631, where in Hartford, Connecticut, further traces are lost. On his mother's side the family history shows a clear genealogical line to an equally early date. The farm whereon he was born, was one selected by his grandfather in 1806 from the wilderness of the Western Reserve. Here, in 1809, Geo. E. Steele's father was born; and in 1845, when he was three years old, his father moved to Kingsville, Ohio, and lived there sixteen years. George's first day in school was spent in what had been a blacksmith's shop in that village, but soon the town and school outgrew the old shop and there for a long time a noted and most successful high school sustained the center of educational influence for the surrounding country, and there he found most of his schooling; interspersing the exercises and vacations with labors of a different kind, using the saw, plane and hammer, as well as the ax, hoe and rake. His familiarity with these articles when younger has never lessened his interest in them, nor in the class of men who have cleared the forests and made honest toil productive.

In the spring of 1861, his father moved from Ohio to Benzonia, Michigan, where the pioneer life was again entered upon with new zeal. The clearing of forests in northern Michigan was no small task and this departure of his father's furnished no opportunities for further home school education; it furnished to George E., however, unbounded facilities for the development of pluck, muscle, energy and the like, and no small share of these qualities are still retained by him. Along with these grew sterling character, mostly ambition and a desire to know more and to be more than the forest life afforded. The building of the log house, the church, the schoolhouse, and the laying out of roads served a good end later on in life.

In 1864 he entered the State Agricultural College, at Lan-

sing, he being the first student to enter from north of Grand Rapids; walking thirty-two miles to Manistee, having his trunk tied onto the mail cart; he took a schooner to Milwaukee, a steamer back to Grand Haven, four days in making the trip, which was considered good time. On his return to the north he married Miss Lois S. Judson, daughter of S. F. Judson, of Medina county, Ohio, and then again commenced in the woods to make a farm. But his recent studies in Lansing had fitted him for other work and the frequent calls to make surveys of lands, to locate government and state lands, and make timber estimates, deprived the farm of a farmer and he soon removed to Elk Rapids, Antrim county, where he gave his entire time to matters pertaining to real estate. In 1882 Traverse City became his next and last place of residence, here forming a partnership with the late C. O. Titus, in real estate, insurance and abstract business. The firm was dissolved three years later by the death of Mr. Titus. Since that time he has been called upon to serve in many capacities for which he is fitted and which no one but Geo. E. Steele could fill. No man in this country has a better knowledge of the products and the location of good "sections" than he, no one is more sought for to correct the lines of county, town or village than he; the best railroad route he knows and the information given by him on these lines has helped many a poor fellow "out of the woods." While he has never sought public honors he has been chosen to fill many offices, all of which he has proved himself eminently fitted to fill. In 1876, while residing in Elk Rapids, he was selected representative by the republican party of Antrim and Charlevoix counties, serving his full term of two years meritoriously. Soon after his coming to Traverse City he was elected a member of the school board and served as moderator from 1885 to 1888. He has also been village trustee, and in both capacities proved a most active and useful officer. He was two years president of the Traverse City Business Men's Association, and has all along been county and village surveyor. His connection with the civil engineers of Michigan dates from the beginning of their organization; he was one of the charter members of the Michigan Association of Surveyors and Civil Engineers, and vice president from their organization

to 1885. He was elected vice president of the Michigan Engineering Society in 1886, acting president in 1887, and elected to that office for the years 1888 and 1889.

In manner Mr. Steele is genial and witty, possessing marked individuality, a capital host, a sought-for guest, an encyclopedia of general informantion, a ready public speaker, and fluent writer. Conservative in all his ways of dealing, he is remarkable for his accuracy and precision. His associations with men inspire confidence in his ability and integrity. Always a member of the Presbyterian or Congregational associations and identified with many charitable and educational organizations, he is most essentially a self made man, endeavoring always to serve noble and unselfish ends. His name is at the head of the list among the active and public men of northern Michigan.

DEPARTMENT OF MATHEMATICS AND CIVIL ENGINEERING.

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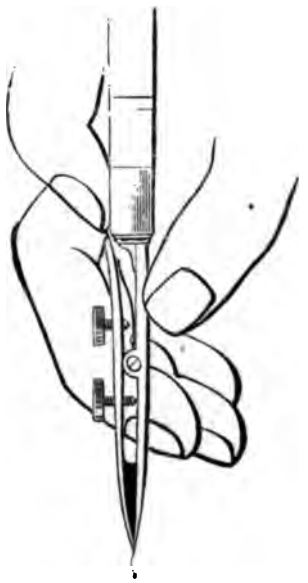

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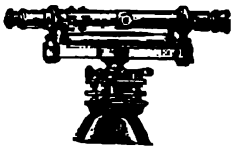

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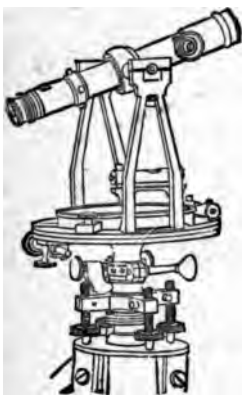

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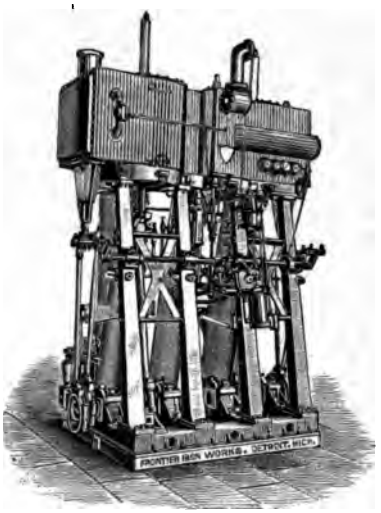

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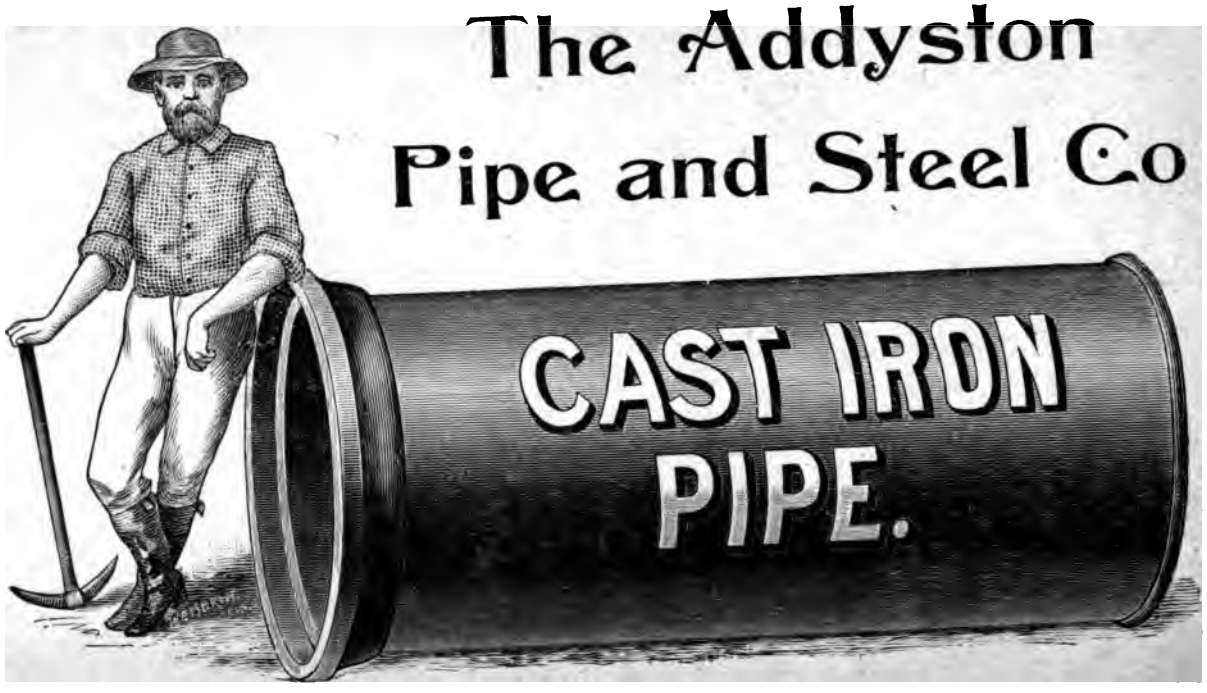

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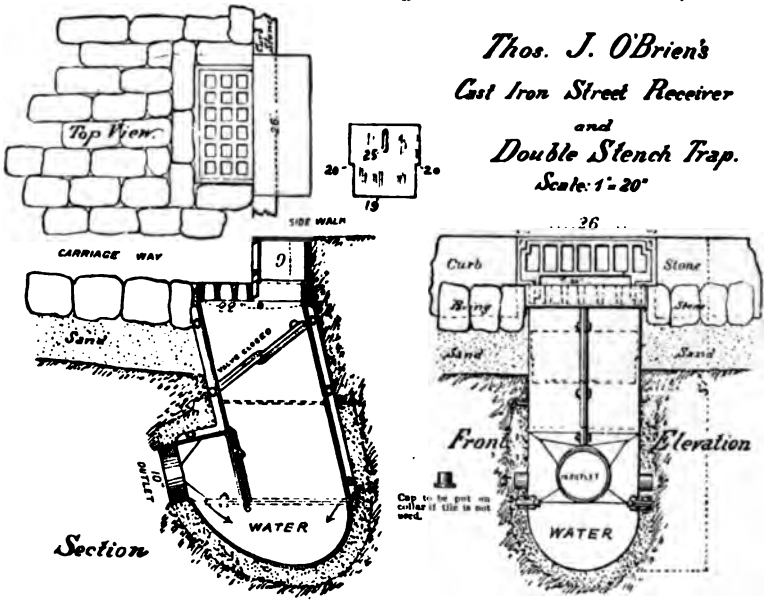

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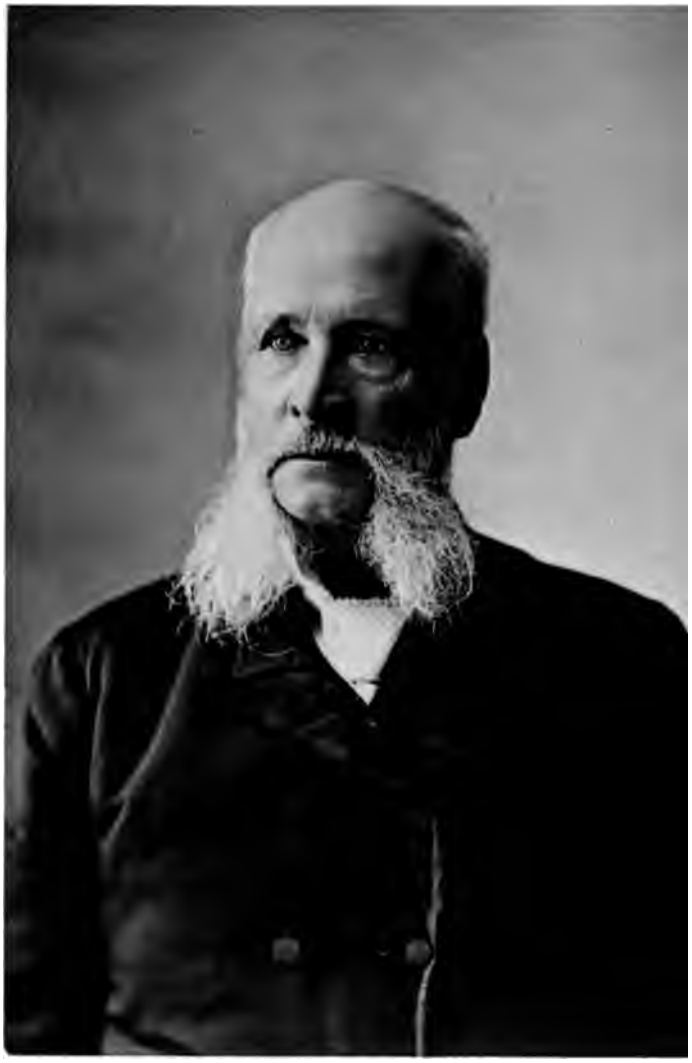

Very Truly Yours
John H. Forst

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AUTOBIOGRAPHICAL SKETCH OF JOHN H. FORSTER.

To Frank Hodgman, C. E., Secretary Michigan Engineering Society.

DEAR SIR:

While I am proud of the interest which you take in me as a comrade, I am free to confess that it is with great reluctance that I undertake to comply with your request, urgently made, to hand you some "field notes," in relation to my life-work as a civil engineer and surveyor. There has been nothing "brilliant" in my career, and all I can say for myself is, that I have always endeavored to discharge my duty honestly and faithfully, under trying as well as pleasant circumstances. The fraternal feeling existing among engineers, emboldens me to write.

Born early in this century, I feel that I have lived in an active, formative period and, not only so, but in the golden age of the republic; simple living, high endeavor, pioneer zeal, have characterized this nineteenth century. Battles for freedom have been fought and won, and civilization has advanced with gigantic strides. Civil engineers and surveyors have done their full share in this work. Their coadjutors, the mechanical engineers, are following close behind—perhaps to take the lead in future. The engineer has explored the continent and laid steel rails across waste places; surveyed vast domains in the face of hostile tribes, and marked out the homes of crowding

settlers; has opened lakes and rivers, far and near, to navigation, and has rendered available the treasures of the mines.

The engineer who has practiced his profession for forty or fifty years, has witnessed a progressiveness, an elevation, an exaltation in that profession, truly marvelous. He can point proudly to engineering achievements that would have astonished his forefathers. The marks of his genius are seen everywhere, between the Atlantic and Pacific; he has battered down the walls of exclusivness, and invaded Japan and China.

I was born at Erie, Pennsylvania, on the 24th day of May, 1822. My grandfather, Thomas Forster, was commissioned a Colonel by Washington, came from Harrisburg to Erie at the head of a colony of settlers, late in the last century. He surveyed and mapped the borough of Erie and owned a large portion of it. My maternal grandfather, Judge William Ball, was a large land holder and prominent citizen. He was a Scotchman. Colonel Thomas Forster's father came from Belfast, Ireland. His wife was a Montgomery. Judge Ball's wife was his sister. Thus the writer of this was of a Scotch-Irish descent. His father and mother were cousins. In the war of 1812, grandfather Forster was Colonel of Militia; he was foremost citizen in Erie and entertained Commodore Perry and other officers of the army and navy. Several of his daughters married officers who, afterwards, became distinguished in history. I write with pride, that both of my grandfathers had wives who loved their lords, each of whom bore fourteen children.

My father, Thomas Forster, first a merchant in Erie, later on became an engineer, and spent a large portion of his life in river and harbor improvements, under the United States Government.

The writer of this paper was educated at the Fredonia Academy and Livingston county high school, New York. Began engineering work as rodman, on the New York and Erie Railroad, in Cattaraugus county. After a time the company failed and the engineering department was disbanded, minus a whole season's pay. First unfortunate venture! For a time engineering enterprises were dormant. The writer,

having nothing better to do, to win bread, tried his hand at teaching a select school and reading Blackstone evenings, in the dull hamlet of Dunkirk, N. Y.

In 1843, catching the prevailing western fever, he migrates, thus anticipating Greeley's advice. Greeley was then a poor printer, and spent some of his time on the hills of Chautauqua. He sailed in a schooner from Dunkirk to Chicago, getting his first impression of the great chain of lakes, whose coast lines he was destined in the future to help survey. Landed after a two week's voyage in the village of Chicago, he encamped at night on the open prairie, in the tall grass, just across the river from the present Tremont House, then a two story white tavern, with the Conch brothers as landlords. Tried his unskilled hand at farming on the bank of Fox river, near Aurora; one year sufficed—on the farm. Returned to Dunkirk, N. Y., broken down financially and physically. The pestilential ague froze the marrow of his bones.

In 1844 the writer joined the lake survey as civil assistant. Our party, under the immediate command of Lieut. Gunnison of the corps of topographical engineers, spent most of the summer in measuring a base line for main triangulation on the north shore of the Straits of Mackinaw, a wilderness teeming with mosquitoes, black flies and *brulots*. It was near the present Mackinaw City. Late in the Fall ran the shore line to Presque Isle. Went into winter quarters at Buffalo. I will note here, that Lieut. Gunnison, a brilliant young officer, some years later, made a survey of Great Salt Lake, Utah, and published a book about the Mormons. Still later, while engaged in running an experimental line of railway from the Mississippi Valley to the Pacific, was massacred with his party by Mormons, disguised as Indians, near Sevier river, Utah. His book was doubtless the cause of his melancholy death. He was a dear friend of mine; it was by mere chance that I was not killed with him.

In 1845 the surveying parties began the survey of Green Bay, Wis. That section was almost an unbroken wilderness, in possession of Indians. Near the mouth of Fox river there was the little town of Astor and Fort Howard. There was a saw mill on the Menominee river. We did a large amount of

work. But before the close of the season the appropriation failed and the parties were disbanded forthwith. The writer made his way in a lumber wagon to the new town of Milwaukee, where he embarked on a steamer, and in due time arrived at Dunkirk.

Went to teaching and reading law once more.

In 1846 he was aroused from his quiet pursuits in the drowsy lake village by rumors of great discoveries of copper in the Lake Superior country, far off in the northwest. Lured by the prospect of great gain, and more by the certainty of an active life, the writer went to Detroit and joined an exploring party as a surveyor. In due time his party reached far-off Copper Harbor and Ft. Wilkins. He sailed across Lake Superior in a small schooner named the Swallow, lodging in the main hold, on pork barrels. He footed it across the portage at the Sault, where one now may see the great ship canal, with the largest locks in the world. He spent nearly two years in that land of frost and snow, working vigilantly as a surveyor, explorer, geologist and mine manager. He learnt much about woodcraft, the sweet uses of adversity, self reliance, and the value of a sufficiency of food and raiment. It was a hard life of toil, exposure and unmitigated hardship. Hours were long. As for fortune, the fickle jade ever eluded our grasp. In 1847 the copper speculation suffered a collapse. Everyone hastened to get out of the accursed country. The writer gladly retired with the rest.

In 1848 rejoined the Lake Survey, under my old commander, Gunnison, engaged on the survey of lake Erie, from mouth of Detroit river to Maumee bay. Happy again in this congenial work!

In 1849 I resigned from the lake survey, having obtained the appointment of first assistant engineer on the survey of the Mexican boundary line. I could not resist the spirit of adventure that lured me on to far distant, unknown lands. Our objective point was San Diego, California. The boundary commission rendezvoused at New Orleans. It sailed thence in a U. S. transport for Chagres, Isthmus of Panama. Arrived at Chagres after a delightful voyage across the Gulf of Mexico

and Caribbean sea, the large party of surveyors was divided and sent up the river in small dug-out canoes to Gorgona. The writer spent several days in a canoe, propelled by two fellows, nude men, with bamboo poles, subsisting upon the country. He could not speak a word of Spanish, nor could anybody he saw understand English. So he got along with "natural signs" very well. Crossed the mountains on foot, suffering terribly from heat; clothing was not necessary as it had been on Lake Superior!

We lay at Panama two months, our lives endangered by fever and cholera—waiting for transportation. By this time the gold discoveries in California were an assured fact, and the Isthmus and City of Panama were crowded with eager, dispairing adventurers, seeking passage up the Pacific to the golden shores, El Dorado. In the month of May, we embarked at Panama, arriving at San Diego early in June. We were six months *en route*.

Landing on Point Loma, the writer spent his first night in one of those famous "hide houses," mentioned by Dana. The 22000 stored hides impress one with their pungent odor and fleas. The next day we entered the adobe built, uninteresting pueblo of San Diego, so long the object of our search. The surrounding hills covered with grass, upon which great long-horned cattle grazed, and the noble bay of San Diego relieved the scene from utter flatness.

After some weeks waiting, the Mexican commission arrived. The officers of this commission were highly educated gentlemen; the rank and file, a mob of *greasers*, many of them taken from prison to serve as soldiers. There were plenty of women in the train.

Fifteen miles above San Diego, or the head of the Bay, our engineers encamped. The writer's first duty was to measure with his party, a marine league south of the southernmost point of the Bay as per treaty stipulation. The south end of the Marine league was to be the initial point of the boundary line, on the shore of the Pacific. This marine league was measured with much care, with a French metre bar and the writer had the pleasure of driving the stake at the point, on a

... the Pacific ocean is forever rolling up

... the writer assisted in making a topo-
... Diego Bay. He found drinking water
... too numerous. Curlews and quail were

... October, 1849, he accompanied Col. Gray's
... veyor under the Treaty,) across the coast
... desert to the Colorado and Gila rivers.
... assumed line of the Boundary, making a
... we advanced. No white man had ever ex-
... Suffering and hardships were concomitant
... In the great desert, north of the Gulf of
... nearly perished from thirst. Our poor mules
... ably; there were earthquakes, and the heat on
... bottoms was terrific. The cool delicious waters of
... Superior constantly returned to my memory with
... enging. With swollen tongue and bleeding lips the
... water was inarticulate, but very real. In the heat of the
... Col. Gray left me to proceed alone with a small party,
... ming to the Pacific with a starving party of U. S.
... 's "carpet bag" custom house. I traveled night and
... the stars were my guide over the shifting sands. The
... Indians were hostile, but we reached the mouth of
... Gila without loss of scalps. A troop of U. S. dragoons
... was stationed there, and Lieut. Whipple, corps topographical
... engineers, had an astronomical camp. *He* fed me; after which
I threw myself on the ground and slept fourteen hours without
turning over. I made a survey of the junction of the Gila with
Colorado, by triangulation; there were no boats, so Dr. Perry,
of the army, and botanist, volunteered to set up my flags at
the mouth of the Gila. He swam the wide, swift-flowing,
yellow Colorado, set up the flags, and returned safely. At this
time the thermometer stood 110° in the shade, and a bath was
agreeable. Finishing the survey at 10 p. m., we mounted our
mules and set out for the Pacific. Passed hundreds of emi-
grants, pushing forward through the sands, for the distant gold
fields. Suffering, destitution, ruin and death marked the long

line of our route. We, ourselves, suffered greatly from want of food and water. But, finally we reached San Diego without loss of man or beast, but ragged as savages and as ravenous.

The commission spent the winter, "rainy season," in the mud hovels of San Diego, subsisting upon hard-tack, coffee and "coone," bull meat. The commissioner deserted us and went to Monterey and was elected U. S. Senator. Col. Fremont, the new commissioner, under Gen. Taylor's administration, we never saw. He too, had the Senatorial bee in his bonnet. The outcome of the whole matter was this: Abandoned by superior officers, without food or pay, the subordinates left to themselves, scattered far and wide.

The writer, having no choice, went to Alta, California, and remained in that section until 1855. He by turns was a day laborer, a farmer, a cow-boy, a swine-herder, a gold miner, a postmaster, a tramp, a Probate Judge, (Public Administrator,) a Judge of County Sessions and escaped being State Senator by coming back to the "States." His patrons and friends, most of them, having been shot in rows, and liking a whole skin better than a possibly eternal resting place in the land of the setting sun, the writer "vamosed."

In May, 1855, by a rapid transition, the writer rejoined the Lake Survey at Detroit. He came home via the Nicaragua route, over lines near the proposed Nicaragua canal. A canal at that point of the Isthmus, seemed to be of no difficult attainment.

The Lake Survey was now under the command of Capt. Meade, afterwards General Meade. The month of June found me with Mr. Wm. H. Hearding, C. E., making a topographical survey of Beaver Island, lake Michigan, under the hostile eye of King Strang and his Mormon disciples. Strang was a man of strong character and considerable ability. Later on he was shot by one of his own people.

1857 I quitted the Lake Survey for the River and Harbor Improvement department—a promotion. Capt. Whipple, U. S. Eng. was chief officer. I had known him as astronomer of the Mexican Boundary Line survey. I was placed in charge of improvements in St. Mary's river, with Capt. Whipple, later

on a general in the Union army, killed by a sharp-shooter at Chancellorville. He had offered me the position of assistant adjutant General in his division, which was declined. He was a dear friend.

I remained two years on St. Mary's river, first completing a canal by dredging through the flats of Lake George, and dredging west channel of Neebish rapids, when I resigned from the Government service, *finally*, to take charge of private work at Portage lake, lake Superior, another promotion! Built a breakwater at mouth of Portage river, during the winter of 1859, cutting holes in the ice to sink cribs in. In the fall of 1858, dredged a channel 1200 feet long, through a tamarack swamp, into the river, and made a topographical and hydrographic survey of the river, a crooked stream five miles long. The season being late, I could only lay out the work and finish soundings before the ice closed the river. After the ice became solid, and the marshes lining the river frozen, I managed to do all instrumental and sketching work admirably. Winter is the time to *do* marshes. But handling my theodolite with the thermometer 10° to 20° below zero was rather *hot* work. Without gloves, the brass screws would *glue* ones fingers instanter. Altogether it was nipping, lively work, but very satisfactory at the end. A large map of the river was made at my leisure, in my parlor at Houghton, my wife and baby being my company. Strange! I had forgotten to tell you of the most important event in my life, so far as I am personally concerned; the happiest event; and the luckiest. Namely, on October 22, 1855, I was married to Miss Martha Mullett, youngest daughter of John Mullett, the distinguished land surveyor and engineer of Detroit. You see, as I am a surveyor, I am fortified on all sides, for, you will notice that my grandfather and father were of the same ilk.

In the fall of 1860, I was appointed chief manager (agent) of the Pewabic and Franklin mines, (copper,) still acting as engineer of the Portage River Improvement Company, and also as director in that company, for several years thereafter. Portage river was opened by the mining company of Portage lake, without assistance from the general government. I

piloted the first steam boat up to the mines. In the course of five years, I finished mine-plants, mills, docks, roads, and tram-roads, for the Pewabic and Franklin mines, and brought both of those mines to a dividend paying basis.

In 1864, the writer was elected to the State Senate—the only Senator from that vast territory, known as the Upper Peninsula. Political office not suiting the habits and tastes of an old surveyor, subsequent honor of the kind, though tendered, was respectfully declined.

Overwork and affliction—the loss of my sweet daughter, and only child, compelled me to resign from the charge of the mines.

My wife and I spent a long vacation in traveling.

But idleness did not bring *peace*. In 1866, I accepted the management of some copper mines, upon which work had been suspended for some time. Built a stamp mill, docks, etc. But the mines were not profitable.

In 1868, I visited southern Nevada, to examine and report upon certain silver mines. I spent the winter in the mountains, suffering much from cold and fearing the Indians, then on the war-path on several lines. Reached San Francisco with a whole scalp in March. Returned to New York by steamer, via the Isthmus of Panama, sweltering under tropical heat. About the middle of May, the steamer I was on, a lake-craft, was stuck fast in the ice, off Marquette, Mich.

Governor H. P. Baldwin, intercepted me in Detroit, and commissioned me as engineer of the State work, namely, "The Portage Lake and Lake Superior Ship Canal." Remained in charge of that work during a period of five years or more, serving part of the time under Gov. J. J. Bagley, seeing its completion. This canal cost about $3.000,000. In the year 1874, much broken in health, the result doubtless of early privations, and with a crushed leg, so imperfectly mended as to render tramping and standing by a transit a grievous labor, the writer, unwillingly, but gracefully as possible, retired to his farm, near Lansing, in Ingham county, Michigan.

The graceful part came from the fact, that he could retire with comfort. Wonderful to relate; for one of his profession,

after so many buffetings of fortune, he had accumulated enough of the "dust," as we used to say in the gold mines some forty years ago, to keep the wolf from the door during a reasonable term of life. On Springbrook farm, surrounded by his gentle Jersey's, his fleecy Shropshires, his pigs and chickens, he is reasonably happy, thank you, "the world forgetting, and by the world forgot."

But like an old man who has passed the mile stone marked 70 years, in his quiet retreat he "delights to fight his battles over again."

In his ample library, he can commune at will with the good and wise of all times, but his heart often yearns for his old comrades who have cast off the veil of the flesh, and are hidden from his mortal eyes.

The writer must fain confess, that the path set for him to travel through the wilderness of life, has not been free from danger and privations of an uncommon kind.

So it is with unfeigned gratitude, that he acknowledges the goodness of his Heavenly Father in rescuing him from so many perils, and he looks to a merciful Savior for ultimate pardon and peace.

"So long Thy power has blest me,
Sure it still will lead me on
O'er moor and fen, o'er crag and torrent,
Till the night is gone,
And with the morn those angel faces smile,
Which I have loved long since, and lost awhile."

—From Lead Kindly Light, No. 512, Church Hymnal.

Very sincerely your friend,

JOHN HARRIS FORSTER.

November, A. D. 1892.

PAPERS AND DISCUSSIONS,

At the annual convention, held in the council rooms at the city of Lansing, Jan. 17, 18 and 19, 1893.

ADDRESS OF PRESIDENT MUENSCHER.

Gentlemen of the Michigan Engineering Society:

In compliance with the custom which requires your president when entering upon the discharge of his duties, to say something bearing upon the interests of this society, I beg leave to touch briefly upon a single point. It is the duty which the members of the society owe it in the way of contributions to its proceedings. I am aware that this subject has been alluded to before, and more than once, but it has been only within the last few weeks that I have begun to appreciate the labors and disappointments which have been the lot of our worthy Secretary for so many years, for I never knew till then how negligent most of us have been.

Let me call your attention to a few facts. Our last Annual showed a membership of 152. Of these but fifty, or less than one-third of the members had, as far as I can learn, ever contributed a written paper to our proceedings. Two others have contributed valuable oral discussions. The remaining 100, or *two-thirds of the entire number have never contributed a single line*, except perhaps to ask an occasional question. Of the fifty who have contributed at all, twenty-six, or more than one-half, have furnished but one paper each. Ten of the remainder have furnished but two papers each, leaving but fourteen, or one eleventh of the membership to furnish more than one-half of the entire proceedings of the society, and out of these fourteen, it is an actual fact that only three gentlemen have furnished more than twenty per cent. of the entire amount.

The mere statement of these facts ought to make some of us pause and reflect whether we have done our duty to a society which gives us so much in return for the trifling fees

which we pay, or rather whether it has not been ungenerous for us to be content to enjoy the benefit of other men's labors, while neglecting to contribute anything ourselves to the common fund.

Much of this neglect is due, no doubt, to want of leisure, but more, I am inclined to think, to the fear that we think we cannot say anything that is new; that what is interesting to us is probably perfectly familiar to all the rest of the society, and that if we write about it, they will look upon our effort as threshing out old straw, or cracking old chestnuts. Just here is where we are liable to make a great mistake. If all of us should wait until we could announce some startling discovery, or develope some new principle, there would be but few papers written. It is only once in an age that a Newton, a Laplace or a Franklin flashes upon the world to discover some great law of nature, or found a new science, but in the meantime thousands of humbler workers, like the minute builders of the coral reefs, have been adding their little mites to the growing mass of human knowledge, which has now become so vast that no one mind can grasp more than a small fraction of it. It is these small contributions that have done the work, each one perhaps serving as the foundation on which another is laid. The steel of one man's thought strikes fire from the flint of another man's brains. So long as they are kept apart they are but cold lifeless flint and steel; bring them together and they may explode a mine, or start a Chicago fire. Human knowledge is still in its infancy and there is still plenty of work for us all to do; new facts to discover; new fields to explore, or old ones to replow. And no field is so vast as the one into which we have been thrown.

Practical engineering science has been largely the growth of the last fifty years. At the beginning of that period, but little was known of the principles which control the construction of city sewerage, the purification of water, the calculation of the strains in bridges, or the application of electricity as a motive force. These branches of the science have all been built up since that time, not by any one great mind, but by the combined efforts of hundreds of laborers,

and still there is abundant room for investigation. To be convinced of the truth of this statement we need only compare the scanty pages of Brunell, and Dempsey, and Hughes, which were the sole dependence of some of us in our younger days, with the great works of Latham and Adams, and Waring, and Pierson, of Fanning and Humber; the first editions of Haupt and Whipple with the exhaustive treatises of Greene, and Burr, and Dubois, and Waddell, or even the first thousand of Trautwine's Pocket Book, with the last.

To show what important consequences may flow from an apparently trifling circumstance, let us take a single illustration from the history of this progress. Less than fifty years ago a bridge builder noticed that the chords of a bridge that had settled were bent more in proportion near the abutments than in the center. He mentioned the fact to one of the most prominent engineers of the day, and enquired what the cause was. The engineer could not reply; he had never observed the phenomenon, but the seemingly simple question started one of the trains of thought and investigation, which little by little, have led up to the present elegant theory of bridge strains.

Our recent field books are not the work of one brain, but rather collections of the happy thoughts and expedients of dozens of locating engineers in solving knotty problems, which had presented themselves perhaps for the first time in their field practice. And the field is by no means exhausted. We have just entered the outskirts. There is probably not a single member of this society who does not see, or hear or do something in the course of each year that is worth telling, and what the society wants, and what it has its annual meetings for, is that he shall tell it.

The great engineering societies of this country and of Europe are spending days and weeks in discussing matters that seemed to be settled years ago, trying new experiments, modifying old rules, measuring the effect of new facts, or the value of new theories, correcting past errors, and even quarreling about whether we should use the square root or the cube root of x in the formula for some insolvable piece of empiricism. And why should not we, in our less pretentious sphere do the same thing.

We, in Michigan, have a wide and varied field of labor of our own. Our lumber camps and saw mills, our iron and copper mines, and our quarries of stone and gypsum, our magnificent river and harbor and coast improvements, might furnish abundant material for papers, which would not only be interesting to us, but valuable outside the State. Other societies are gleaning in similar fields elsewhere, while we are neglecting our own. Why cannot some member from the northern counties take us into a virgin pine forest, and show us how to select camping grounds, to erect and furnish the buildings, to lay out the roads and organize the lumbering force; what tools are used, how the cutting and skidding and loading is done, how the roll-ways are broken, and the logs run to the mills, what each man ought to do, his wages and the cost of his work. Why could not another describe the modern machinery and processes by which the logs are taken from the boom and manufactured into lumber, with the score of little expedients which may make the difference between success and failure. No doubt, many of us have spent hours watching with ever fresh interest the isolated details of these industries, and could listen with equal interest to a connected and intelligent account from any one who was familiar with the whole subject.

Why cannot some one else explain how the wells are sunk which draw from the deep caverns of the earth the vast treasures of Michigan brine; the machinery employed, the difficulties met with, and how they are overcome; how the wells are kept in working order, and the brine which they produce converted into salt?

Why cannot those who have had experience in our river and harbor improvements, tell us how the works are constructed, the principles which control their design, and the difficulties to be met and overcome? Mr. Ripley has given us some excursions into this field, but we all have an appetite for much more. Our Northern Peninsula mining regions might furnish a feast of whose richness we may judge by the choice bits which we have had from Mr. Forster. The plaster mills of Grand Rapids; the stone quarries of Ionia, and many another

local industry might furnish the material for a valuable paper. All these things become so perfectly familiar to those who see them every day, that they unconsciously acquire the feeling that everyone else must be just as familiar with them as themselves, and yet I venture to say, that there are not five members of this society who could not learn much that would be new and interesting to them on any of these subjects. I might even go further and assert that an enterprising, wide awake newspaper reporter would find out in a few hours investigation, a good many things that none of us have thought of, to say nothing of numerous other things that are *not so*.

The economical geology and mineralogy and botany of Michigan furnish wide and almost fresh fields for investigation and discovery. How many of us could accurately describe the geological structure and history of our own counties, or all the varieties of timber to be found on their soil, their physical characteristics or the most profitable uses to which they can be applied.

There is still another extensive field in which some of our members might find material. Our city engineers might give us at each meeting an account of their past year's work, the experiments they may have been trying in new materials or methods for paving, or sewerage, or water supply, or perhaps the plan and treatment of a new public park. Several of our cities have been recently laying asphalt pavements. Who can tell us how they are succeeding under the extremes of heat and cold of our Michigan climate, or whether it has been found necessary to change the usual specifications to meet these conditions? Our railroad engineers might furnish us each year with maps of the lines they have constructed or surveyed, with the elevations marked on them, and the character of the soil and timber, and thus with little labor, add something each year to our knowledge of the topography and natural features of our State. Indeed, so many things occur to my mind which each one of us might have done that I am ashamed to further expose my own negligence.

Let us all resolve to do our part next year, even if it be but

a single page—without compelling our long-suffering secretary to ask us a second time.

In conclusion, gentlemen, permit me to express my sincere thanks for the unexpected honor which you have done me by electing me your president, and the hope that our relations may be mutually pleasant and improving.

E. W. MUENSCHER.

MR. APPLETON: There are so many suggestions in our President's message that go right straight home, that I would like to see it referred to some committee who would make some report on it. I move the appointment of a committee to take into consideration the President's opening address.

Motion being supported and carried, Messrs. Appleton, Granville and Skeels were appointed to act on the committee.

The committee having given the matter due consideration, made the following report:

To the President and members of the Michigan Engineering Society.

GENTLEMEN: Your committee appointed to consider the President's address, has very carefully considered the matter of preparing papers by members, to be read at the annual convention. We find that many members do very little towards providing matter for the good of the Society, in return for the valuable information they receive in the annual reports of this and other similar societies. Your committee admit to being somewhat perplexed to provide a remedy for this direliction of some of its members. We believe that in many cases this results from a feeling of diffidence which prompts many to think they have nothing new to say, or of interest to all members of the society; this mistaken notion keeps many pens idle, which might give many bright and valuable hints to the profession. Others are always ready and willing, and these are the contributors who fill our annual reports.

We dislike to heap more work on our secretary, but as the secretary and president are the best acquainted, and con-

sequently are the best qualified to carry out the idea of making a personal request of any member to prepare a paper for the use of the society, on any subject desired, and which request will tend to spur on modest members to give us their knowledge and make all partakers in their skill and ability, we recommend the adoption of the following:

Resolved, That when any information of any subject is thought to be for the interest of this society, the president or secretary, or both, are requested to ask any member of this society to prepare a paper, giving his knowledge or ideas on the said subject, to be read at the next succeeding annual convention, and it is the duty of every member to comply with such request.

Nothing in this resolution is to be construed to discourage voluntary papers by members, on such subjects as they think may be of interest.

Respectfully submitted,

WM. APPLETON,
JOHN GRANVILLE,
D. SKEELS. } *Committee.*

Report adopted.

Motion for the appointment of a committe on questions of practice being put, supported and carried, Mr. Hodgman, Mr. Strong and Mr. Rogers were appointed to act on the committee.

THE PRESIDENT: What is the pleasure of the meeting; are there any committees ready to report at this time?

MR. HODGMAN: I think there is only one standing committee that was to be called upon for a report now, and that is the committee on the World's Fair business. I was elected last winter as a member of the committee, to take into consideration the question of accommodations for the Michigan Engineering Society at Chicago, during the World's Fair. The thought was that the Civil Engineering Societies of the country were uniting together for the purpose of providing entertainment for all engineers who came from abroad to have a special place of meeting, and the thought was that we might take part in such a movement as that. On investigation

I found that all engineers who wished to avail themselves of the privileges of this society, could do so by paying $5.00 a piece. My feeling was, that the Michigan Engineers, as a Society, wished to have nothing to do with it.

We have organized a local society in Kalamazoo—two members of this society are also members of that, Mr. Wm. J. Kirby and myself. They have obtained a good lot and are going to put up a building for the accommodation of the Kalamazoo people and those of the Michigan Engineering Society who wish to make arrangements for a home there. The arrangement is to furnish rooms suitable for two persons. The rooms will be rented at $1.00 a day. Any person wishing rooms can apply to the secretary of the society at Kalamazoo, stating at what time they want rooms, and have the rooms reserved for them. Nothing to pay until they have the rooms. It is two and a half miles from Jackson Park, and in connection with several roads, and we are planning for about sixty rooms.

MR. APPLETON: Is it for Kalamazoo people, irrespective of Engineers or anyone else, and are we allowed to become beneficiaries of this institution?

MR. HODGMAN: We propose, if the Michigan Engineering Society want accommodations there, to make arrangements to furnish them, only we would like to know before putting up the buildings, whether the society propose to avail themselves of it.

SOUTHERN CALIFORNIA AND ONE OF ITS WATER SYSTEMS.

PAPER BY A. L. REED.

The arid lands of the western portion of the United States and their reclamation is a question in which many are of late years becoming interested. As long as the fertile prairies of Illinois, Iowa, Kansas and kindred locations furnished such desirable fields for agriculture and gave such quick and oft-times easy and large returns for labor and investment, the development of the arid portion was little thought of by the general public, and only to the few was their real value known; but in the last few years the capabilities of these soils under skilled treatment, coupled with the salubrity of the climate in which some of them were located, and the almost fabulous returns they have yielded to their owners, has made the question of their development of special interest to many.

In character, as well as location, these arid lands vary greatly, the soil being all the way from a light sand to the heaviest clay and adobe, and the elevation from considerably below the sea level to several thousands of feet above. On most of these lands the annual rainfall is insufficient, and its precipitation confined to so short a period that without being watered by artificial means, crops cannot be produced at all, or only to a very limited extent and in favorable seasons.

The scope of an article of this kind is too limited to go into extensive generalizations, and will perhaps serve its purpose as well by confining it in general to the semi-arid lands of the coast region of Southern California, and especially to a single water system as therein developed; and to such limits will this paper be confined.

Lying westward from the Sierre Madre Mountains, and between their base and the Pacific Ocean, are the once semi-arid valleys and mesa lands of Southern California. These valleys differ somewhat in their conformation; the upper

valleys being in nearly all cases separate and distinct from the lower, the separation being made by a range, or ranges of hills. The upper valleys assume in many cases the form of more or less well defined basins, hollowed out, perhaps by glacial actions, and afterwards somewhat filled in with drift, and the wash and deposits from the stream; the lower valleys between the hills and the ocean, assuming the form of a broad sloping plain with comparatively smooth surface.

The streams as they issue from the mountains in narrow, and oft-times precipitous canyons carry, especially in times of flood, immense quantities of boulders, cobble stones, gravel, sand and silt which is deposited in the order named along their courses. Thus by annual deposits, the streams raise their channels above the adjacent lands and in time of flood often break away and seek new channels, leaving where the former channel was, only a mass of boulders, cobble stones and gravel; and oft-times impinging against a higher point of mesa land, cut it away, and with the sand and silt already in the water, carry it down to the lower valley to be deposited over large areas, making a very rich covering, but at the same time making the locality very uncertain in its character; for this season you may be on one side of the stream, the next on the other, and still the next in mid-stream.

The dip of these basins is, uniformly, from the mountains to the hills, and from each rise that separates the basins, toward the main stream and toward the point of its break through the hills into the lower valley. The lower valleys have numerous small streams breaking from the mountains, but they all find their way, when their volume is sufficient, into the main streams of the upper valleys, so that only main streams cross the lower plains, with perhaps the exceptions of the excess flood water from short canyons in the hills which, however, are soon dry.

A word of explanation just here, to those who are unfamiliar with the streams of the arid regions: They run, many of them, during the greater part of the season, as the expression is, "bottom side up," the sand on the surface and the water below, so that where in times of flood are wide, but shallow streams,

for the greater portion of the year is a small rivulet, or perhaps a broad expanse of boulders, gravel and sand. Many streams that emerge from the mountain canyons, quite large in volume, within a few miles have entirely disappeared and no water will be seen for miles, when they will gradually appear again in springs and form quite a stream, flow a few miles and again disappear.

The lands of the upper valley vary very much, running from a fine sedimentary sand to heavy clay, adobe, gravel, and in places almost entirely disintegrated granite. The lower valleys vary nearly as much, except there is an entire absence of the boulders and granite sand, and more of the fine alluvial deposits and some peat land near the coast in certain localities. Such in brief is the character of the streams, valleys and soils of the semi-arid region of Southern California.

Here, but a few years ago, and still to some extent, large herds of cattle and sheep found winter pasture, and the wolf and coyote roamed at will. Now the valleys and mesas are dotted with cities and villages, and covered with fields of waving grains, orchards of oranges, lemons, limes, olives and all kinds of delicious fruits, groves of stately eucalyptus, graceful pepper trees, with here and there palms, magnolios, and semi-tropical trees of many kinds. What has made the change? Simply the intelligent use of water. Where this water is secured, how conducted, how used, let us examine.

The earliest irrigation works were of the rudest sort, if indeed they could be called works at all. A settler, or a community of them, select some of the smooth, low lying lands adjacent to the stream and, going a sufficient distance above, dug a ditch having less fall than,—and gradually working back from—the stream, so as to bring it to the back or high side of his land, from which point it was distributed over it in rude ditches or plow furrows, and handled in a very primitive manner; the ditch being filled with water diverted from the main stream by a rude wing dam of willow bush and stakes which were washed away very often, and as often renewed, until the season's needs were supplied.

Many of the older water systems are still little better than

the one just described, although most of them have, at this time, some more or less modern appliances and methods.

However as the settlements increased, and the higher lands were occupied, and found to be in many respects more desirable than the lower ones, they were obliged to seek water from higher sources, carry it longer distances and by more skillful means. Finally, in the lower valleys the limit of the elevation was reached. Fine land lay above the highest water —high up the river there was no water, at least in sight— and a supply must in some way be found and perhaps conducted a long distance. To some of these more extensive systems let us briefly turn our attention. First, as to the sources of supply:

The lower valleys, in the primitive method just mentioned, soon appropriate all the lower flow of the streams; the upper valleys go to the mouth of the canyon and there divert the entire flow for their especial service, but this is not sufficient. The great flood stream of the rainy season must be secured, and held for distribution. Suitable locations are located, or settled in the mountains, dams built, and an immense quantity stored and distributed when needed. Notable examples of this method are the "Bear Valley," and "Sweetwater" dams, of which enterprises and the brains that conceived and the hands that executed, too much in praise can scarcely be said.

Tunneling into the hills and mountains, tapping springs and the underflow of streams, is another method that has, in some places, been very successful. Another, which is now receiving much attention, and which is being eminently successful in many places, is the development of the deeper subterranean water by means of artesian wells.

There has, in the region under consideration, been developed from a single well a flow exceeding two cubic feet per second.

Along the lower margin of the lower valleys these wells are very numerous, and in few cases has there been a failure to secure a flow; but most of the wells are of inconsiderable volume and only serve to irrigate a small area in their immediate vicinity; hence we shall give them only a passing notice.

In the upper valleys, however, there appears a different order of things. The different basins heretofore mentioned appear to be as entirely distinct in the subterranean, as in their surface waters and to have no connection, each with the other, and even different portions of the same surface basins appear to have their under surface waters entirely separate.

The "San Bernardino Basin," so called from the county and city of that name, has been the most developed, and has, and is, yielding large quantities of water. The San Bernardino valley lies almost wholly in the county of San Bernardino and is abruptly hemmed in on the north by the rugged Sierra Madre Mountains, while close on the east, tower the lofty peaks of Mount San Bernardino and Grayback, and on the south, by a range of hills extending from the mountain base to the hills of the Coast Range. Entering it from the northwest, in the Cajon (Cahoon) pass, from the extreme eastern end is the Santa Ana river; from the southeast comes in the San Gorgonio Pass, and between these, various smaller streams, some perennial and many only showing on the surface a portion of the year.

This basin has an area of about one hundred square miles, of which the artesian portion, as thus far developed, is something like twenty square miles. The artesian development of the Gage Canal system is in this basin, and the average of the first twenty-nine wells was thirty-three miners' inches per well. A legal miners inch in California is one fiftieth of one cubic foot per second.

The city of San Bernardino obtains its supply from the same basin, and there are various other systems of which there is no time to speak.

The development to which I shall briefly call your attention, is in Los Angeles county, and in what may be called the "El Monte Basin," of the upper San Gabriel valley, and through which, during the wet season, flows the San Gabriel river, which drains a mountain area of about two hundred and twenty square miles of rough rocky surface. The entire summer flow of this river is diverted at the mouth of the canyon, and supplies quite an extensive region contiguous thereto. There is below this division, for ten miles or more,

no surface flow; then, in the El Monte Basin, the water again gradually appears at the surface, and by the time the gap in the Coast Range of hills is reached it has become, from the springs and the inflow of some spring brooks, a considerable stream. All these waters are again diverted and used in the lower valley within a few miles of the Pass and the lower portion of the bed is again entirely dry.

The El Monte Basin is located in the middle of the upper San Gabriel valley, and the river at the point in question, just begins to show upon the surface.

In 1888, some Michigan gentlemen, who owned a tract of land in the lower valley, close against the foot-hills, and above the irrigation water of the valley, having failed to secure water by tunneling into the hills, determined to make the experiment of developing water in the Basin above referred to; and to that end, made a trial cutting, and sunk a test well, in which cutting they secured a generous flow from the gravel strata immediately below the surface and from the well a flow of about one fifth of a cubic foot per second.

Nothing further was done until 1890, when the writer was called upon to go and make a development cutting, and sink a series of wells, and if successful in securing water in sufficient quantities, to construct a main and distributing system, and a complete pumping system for the lands above the gravity flow. This system I shall briefly describe.

The fall of the river wash or bed through the El Monte Basin is from twenty to thirty feet per mile, and is simply a broad expanse of dry sand and gravel. On either side of the channel are benches a few feet higher, of similar material. Commencing at the lower end of a strip of land owned by these parties, which lies alongside and parallel with the wash, a Marion Steam Shovel was set at work. The cutting began at about six feet depth and gradually cutting deeper, running on a grade of about four feet per mile. This work was kept going with varying progress for about ninety days, and had cut into the sand, gravel and quicksand a channel more than one half a mile long, and from six to sixteen feet deep, and from twenty to sixty feet wide.

The material was very difficult to handle, or rather an excessive amount was necessarily handled, as from its nature, it caved and slid in very badly at times. In the bottom of this cutting was placed in sections, and secured, a wooden flume, four by six inside measurements, with cross sills of two by ten; longitudinal sills of two by ten; side posts and caps of four by four; and two inch plank sides; all of strong Oregon pine, and well spiked.

The excavation was made somewhat below grade line, and after the flume was secured in place, this bottom space was filled with coarse gravel to serve as a check upon the sand rising in the bottom, and, after two years of service, very little sand had come through the gravel bottom. The back filling along the sides was also made of coarse material, to allow as free percolation as possible from the quicksand and water bearing strata through which the cutting was made. From the cutting a flow of one hundred and fifty inches, or thereabouts, was secured.

During the progress of the cutting and fluming, work was prosecuted on artesian wells, and twelve were put down to depths varying from eighty to two hundred feet. Each one gave a greater or less flow, varying from one tenth to over one half of one cubic foot per second.

One remarkable thing about the wells, is the exceeding irregularity of the strata through which the borings pass, although in some cases they are within one hundred and fifty feet of each other. Although invariably a stratum of impervious clay was passed before a flow was secured, in some cases the clay was only a foot or less in thickness and in some cases twenty feet thick.

The method of sinking the wells was the ordinary sand pump, run by horse power, and was very rapidly and economically performed, the twelve wells complete costing less than two hundred dollars each, and being cased the entire depth with number sixteen double casing.

Having within ninety days developed nearly four hundred inches of water, we were warranted in proceeding with our work of constructing our main conduit and in order to do

this, must determine its grade, size, capacity, manner of construction, etc.

It was finally determined to make the conduit to carry fifteen hundred miner inches, or thirty cubic feet per second, on a grade of one in four thousand, with Portland cement, concrete sides, and bottom of the following dimensions. Neat bottom width, four feet, width 8″ below top, and at top six feet, depth 3′ 4″ figuring on a neat depth of water of three feet. The flumes, of which there are several aggregating over six thousand feet in length, are 4′ 6½″ wide, 3′ 4″ deep, and will be described in detail later.

Beginning at the lower end of the developement cut, the line of conduit runs a few hundred feet along the lower bench of the valley and strikes the foot of the bluff, and following along the line of, and gradually creeping up to a mile below, it is upon the mesa, upon the bluff; from this point the line strikes directly across the main valley of the river, by a flume and trestle, four thousand three hundred feet in length, to the mesa on the opposite side, thence across one quarter of a mile to the Puente Creek valley, which is crossed by a flume and trestle nine hundred feet long, and an extreme height of forty feet; the line then strikes the main range of the Puente hills, along whose steep sides and sloping base it follows for several miles till it crosses Sycamore Canyon on to the smooth sloping mesa, where it follows around the grade line in easy curves through the village of Whittier, to the East Whittier tract, which land it is the primary purpose of the enterprise to supply.

Along the hillside, in many places, too steep to more than obtain a foothold, the benching in was begun by hand, until sufficient width was secured to work a single horse or mule, when the material, when practicable, was plowed and pushed off by a side-hill scraper or "vee," until the grade line was reached, and the bench was eight feet wide and ready for the excavation; for the entire work has been made in excavation to avoid settling and washing away of embankments.

The first section of the work was put in December, 1890, and January, 1891. The excavation being in a fine soft sand,

the concrete was made of one part of Portland cement to ten of sand and gravel, just as they were taken from the river wash, very clean and good.

The specifications were one cement, three sand, nine gravel; but suitable material being found as stated, without screening, it was used one to ten, and made a very satisfactory piece of work. The larger portion, however, was made one to eight, the main body of the sides and bottom being 2½″ thick, the corners being reinforced and the upper 8″ being vertical on the inside, the outside having a uniform slope of one in three.

It may, perhaps, be not uninteresting to briefly describe the method employed in the work.

The excavation was first made to a templet the exact size of the outside. It was excavated by hand as it was found inexpedient to use teams, except to plow and loosen the material, and then strong horses were used tandem. The men became very expert in making the excavation the exact dimensions required, as, if too small the inspector objected, and if too large it took more concrete than the contractors liked.

Light skeleton forms were made of two by three pine, connected by one by four side strips, each being twenty feet long, and well braced. These forms were light enough to be easily handled by two men. They were placed in the excavation, neatly adjusted to position, and held firmly in place by iron pins driven in the bottom. One inch by twelve boards were used for the sides, put in one at a time, and the space behind them partially filled with fresh concrete, which was thoroughly rammed and packed; each layer or course being not to exceed 6″ in height; after ramming, the sides were carried up thus the width of 3-12″ boards, then an 8″ strip placed vertically completed the form. Behind this 8″ strip were placed thin wedges that were easily withdrawn, when ready, and the 8″ strip loosened and lifted out when the entire frame work was easily taken out, and placed on the bank, leaving the lagging to be taken out one board at a time. The alignment in places being very crooked it was found difficult to adjust the ends of the frames and lagging, and to obviate this strips of sheet

iron was used at each joint, which fitting behind the ends of the adjacent lagging boards covered the joint and greatly facilitated the work, these joints being the thickness of the iron —thinner than the remainder of the wall—were plastered over as soon as the forms were taken out.

The concrete was mixed at intervals on platforms of boards and shoveled directly on to a low hopper car running on a portable wooden track of two by four, laid in sections on the upper cross pieces of the frames. In this manner the mixing places could be made three to four hundred or more feet apart and the material delivered at the exact place it was to be used, and with a completely organized crew it was possible, and we did many times, put in as high as seven hundred lineal feet per day of completed concrete work.

As soon as the frames were removed which was as soon as the material had sufficiently set, a man, with fine mortar and trowel, followed, smoothing up the rough places, filled where necessary and trimmed up the work. Following him came the bottoming force who spread the concrete evenly over the bottom to the necessary thickness and thoroughly rolled it with a heavy hand roller filling the corners flush and tamping by hand. As soon as the walls were sufficiently set, they were given a heavy coating of neat cement wash of the consistency of thick cream, applied with a heavy white-wash brush, which gave the wall a good finish, filled the pores and made it water tight.

The concrete conduit is covered the entire length with pine or red wood plank from two to four inches thick, spiked to three two by three longitudinal strips with 20d spike. The outside strips are pressed firmly against the vertical face of the concrete and make the whole very firm and solid. The planks except through the village and in special places, are not covered with earth and are cleaned of all dirt and rubbish each season. At intervals of two thousand feet or at each 6″ fall, bulk-heads are placed, or rather slotted recesses are made with concrete so that flash plank can be slipped in them, making a reservoir of the entire conduit if necessary. At intervals not exceeding one thousand feet, are placed man-

holes and ventilators in the covering made two feet square at one end, nothing at the other; the large end screened by a removable screen of six by six, mesh number 22, galvanized wire; these are secured in place by a common lag screw whose head goes into a countersunk casting so that it can only be reached and turned by a special socket wrench.

At convenient points, when necessary, outlet valves are placed solidly in the concrete 8, 10 or 12″ opening, with a planed faced slide valve through which the water may be let out for any purpose, and below these gates suitable weirs for measurement are constructed. At intervals suitable waste gates are provided, and near the upper end are several sand boxes for catching and dumping any sand that may be deposited.

This method of construction is practically a new thing in California, no very extensive work of the kind having been, as far as I am aware of, previously attempted; nearly or quite all cemented conduits having been very small, or else having a cobble stone or rubble backing, with cement pointing or facing. This system has so far been a success, having stood some of it over two years and doing good service.

The six thousand or more feet of flumes in the system are built of 2″ Oregon pine dressed, shiplaped and asphalted, and present no special feature of construction. Across the main river valley the trestle consists of three pile bents of ten by ten pine piles well driven, spaced twenty feet centers; the outer piles sprung to a slight batter, 8 by 10 caps drift bolted, 4 by 14 stringers, 4 by 6 ties spaced, 4 feet centers.

The flumes as well as the development flume are all covered with 1″ redwood to prevent any contamination of the water, which is of the finest quality, and to prevent the growth of moss and fungi. The short trestles across canyons are on redwood mudsills and are lighter, six by six main and four by six batter posts with the ordinary diagonal and longitudinal bracing. The main system as at present constructed is about eleven miles in length, and has in connection at the lower end a complete pumping plant, reservoir and distributing system, to supply the lands above the gravity flow, and close to the hills

which are practically frostless and very valuable for the raising of lemons and winter vegetables. The plant consists of a complete set of pumps of the well known make of our own Mac Walker of Port Huron, of one million five hundred thousand gallons daily capacity.

The water is taken from a pumping cistern ten feet in diameter and ten feet deep, and pumped through about thirty-three hundred feet of 8″ Kalamein pipe to the reservoir, which has a capacity of eight hundred thousand gallons.

Connecting with the main, are the distributing pipes with outlets with gates as required. At each outlet is built a weir box of Portland cement concrete of varying size according to the pressure on the pipe, the less pressure the smaller the box may be, as the surface of water in the box and over the weir should be reasonably smooth in order to secure accurate measurement. The measurement over a weir is coming to be the usual form in use, instead of the square inch under a 4″ pressure, and is much easier to handle and regulate. The weirs on this system, that is, on the pipe lines, are all twelve inches wide and on the back of the weir boxes is placed a scale graduated to one-fourth inches. In the use of the water, the depth of flow and time are noted and recorded, and the flow per minute in gallons taken from a table prepared for the purpose, and has been very satisfactory.

In June, 1892, over six million gallons were pumped and the record of water used was within about fifteen thousand gallons of the same amount. Meters are used on all service connection. So far the Crown and Nash meters have been used.

The reservoir is seventy by one hundred and seventy-five feet in size at top, twelve feet deep with inside slope of one to one, and cemented four inches thick with Portland cement concrete, given two coats of neat cement wash; it is tightly covered with a light roof of sawed redwood shakes, and well ventilated at top and ends and all openings screened.

From the weir boxes the water is conducted either in cement or vitrified pipes under ground, or in small flumes of redwood, or in small surface ditches to the points desired on each subdivision, or lot, and from these points distributed over

the surface in various modes of which in detail we have no time to speak.

From this brief sketch you get some little idea of a water system and in general of the lands and waters of Southern California.

There are thousands of acres of the most beautiful lying lands still unimproved, and ample water yet undeveloped and unstored to bring them all into utility. It requires only capital and skill and a little time to accomplish the end and make "Our Italy" as nearly like the "Garden of Eden" as is possible on this earth on which we live.

MR. HODGMAN: There is one thing I want to say in connection with this paper. I do not think there is a harder working man in the Michigan Engineering Society than Mr. Reed. He has practically everything to do, engineer, superintendent, book keeper and everything else. He doesn't have a minute to spare, but whenever he could find a minute, he sat down and wrote. The men who really have the most work to do are the men whom we can best depend on to do their share of the work of the society.

MR. JOHN RANDALL: This question of cement lining is quite interesting to me, because I tried such a thing four years ago. It was in loose sand, and with only one and one half inches of cement, we hold water to the depth of sixteen feet. It has been in use four years without any leaks. I recommended that the sides should be bricked up and the bottom should be concrete and the sides and slopes should be brick, but the capital of the company would not warrant that, and they told me that I must arrange on something cheaper. As an experiment, – I thought it was an experiment to make such an egg shell as that– but we dug it out, being very careful not to disturb the sand as it was originally put down, not to break the walls, and just before the cement was put on, the mason went ahead with the trowel and shaved it down to the undisturbed sand, and put one layer of cement on while it was yet moist. We did not use any gravel in the concrete, but used a very good quality of sand, using about five of sand to one of cement.

MR. GRANVILLE: Is this a reservoir, carrying sixteen feet of water, with only a 1½ inch wall to hold it, with nothing in the bottom to hold the soil?

MR. RANDALL: Yes, but it has a good many feet of natural soil.

MR. GRANVILLE: I know, but on the bottom. Would the weight of the whole structure help strengthen the walls?

MR. RANDALL: I think the only strength it has, is in the natural packing. The land has been there, we don't know how long, pressed down by the soil above it, until it is more solid than we can get it, in any other way.

THE PRESIDENT: What slope did you give to the sides?

MR. RANDALL: We made it egg shaped, except that we had a flat place on the bottom. I think the slope as it started near the top was about one in eight, and then the slope grew greater.

THE PRESIDENT: Then it was a good deal steeper than the natural slope?

MR. RANDALL: Yes.

THE PRESIDENT: It would be difficult, it appears to me, to keep the sand from sliding in while getting the plastering on?

MR. RANDALL: We did not allow the excavation to get ahead of the plastering. We put on a thin coat to hold it, and waited until that was set before going any further. It did not cave a particle.

MR. APPLETON: It must have been a good place for that kind of work?

MR. RANDALL: Well, it was all sand.

MR. APPLETON: You couldn't use a form?

MR. RANDALL: No, just plastered right on the sand bank. It was a very simple affair, but in a good many places it would not stand.

MR. APPLETON: That is a new idea to me. I don't think under the circumstances, I should have thought of holding that much of a head of water with that amount of plastering, but I don't see why it wouldn't work.

MR. RANDALL: The natural soil holds it. The plaster is merely to keep it from leaking. I would be almost ashamed that I had any connection with such a job if it hadn't stood for four years.

MR. HODGMAN: If I understand, it was nothing more than a big cistern.

MR. APPLETON: What kind of cement did you use?

MR. RANDALL: The best Portland cement.

MR. BEAN: Commencing at the top and working down?

MR. RANDALL: Yes, we dug the sand away all around the margin to the depth of a few inches, and then plastered right on to the bank, and so on one course after another as the sand was excavated from the resevoir.

MR. HODGMAN: It seems to me that is the distinguishing point of the whole thing, *i. e.:* the manner in which the work was carried on. This was simply a big cistern, and I have seen lots of cisterns dug in the sand and plastered over with cement without any backing, which held water and stood indefinitely. I have one myself, egg shaped, which is ten feet deep, and holds over forty barrels. The hole was dug, and it was plastered right into the sand about an inch thick with mortar made from common water lime and sand. The top is arched over with brick, but the first layer of brick was laid right on the sand at least six feet above the bottom of the cistern. That has stood nearly twenty years without cracking or leaking.

MR. SKEELS: Mr. chairman, I think the principal point is the absence of any thicker backing.

MR. RANDALL: The natural earth is there, and before it was excavated, the weight of a cubit foot of the original earth was probably more than the water to be put in there afterwards. The natural soil is backing enough, and therefore you are going to a needless expense in putting in brick, etc. As far as holding the water, the natural earth is enough.

THE PRESIDENT: I do not consider that it is at all remarkable that it will hold water—it is stronger after it is full of water.

MR. APPLETON: The trouble would be at the time it was empty. You get a pressure of ten feet of water at the bottom of that well, and if the earth is at all compressible, a thin wall like that is liable to crack. The pressure at the bottom of that cistern is a good deal heavier—it isn't like a body of earth.

MR. HODGMAN: Isn't sand about the least compressible earth we have to deal with?

MR. APPLETON: But in speaking of the resistance from the inside or outside. The resistance is practically the same at the bottom and top of that well, on the outside of the well where you have the backing of sand, but the pressure is greater at the bottom of the cistern full of water than it is at the top.

MR. RANDALL: You have got to bear in mind that this is egg-shaped, and the pressure from above would distribute it all over.

THE PRESIDENT: I suppose that the safety of the structure arises from the fact that you were careful not to allow any loose material to get in the lining. All of us know there is nothing better than sand, so long as you can keep it confined. It is better than solid rock, provided you can only keep it confined, and in this case the precaution seems to have had its effect; but it certainly is an extraordinary case, and it is just these little tricks of the trade that we ought to have brought out in these meetings of ours.

MR. GRANVILLE: How was the water put into the cistern after it was finished?

MR. RANDALL: Pumped in through a pipe in the side. There was a four inch main put in while the reservoir was being constructed. The last thirty feet was driven from the inside, by working the dirt out of the inside of the pipe, so as make sure that the sand was tight outside of the pipe.

SPECIFICATIONS.

BY G. L. WELLS.

Specifications prepared for proposed engineering works are for the purpose of giving every person connected with the work an accurate idea of the *quality* of the work to be performed and materials furnished. They should also include a statement of quantities, as nearly as can be arrived at from the amount of preliminary work which the projectors choose to spend in gathering the necessary data.

Most corporations having work of any magnitude invite contractors to bid upon it, offering as the basis of the bids and contract a set of specifications, descriptive of desired materials, manner of placing, and quality of workmanship.

The specifications are supposed to have been prepared by a competent engineer, whose skill and experience will be manifested in the specifications themselves.

But is this always the case? An advertisement for bids generally secures a number of proposals from reliable contractors who desire the contract for the profits which can be realized by their skill in management.

As labor and material cost money, the contractor has to figure upon the cost of these in making up his proposal. When he comes across a paragraph like the following, how can he determine quantities to be used?

"All mortar used for masonry and concrete shall be made of fresh hydraulic cement, of such brand and strength, and mixed in such proportions as shall satisfy the engineer in charge."

It is a principle in law, that in making contracts, minds must meet.

Where could minds meet on the quality of mortar to be used by such a description, when cements are in the market which vary in cost from 60 cents to $4.00 per barrel, and the proportion of cement to sand are demanded from ratios of 1:1 to 1:3?

The mind of the bidder at least, in this case, is puzzled instead of meeting the mind which produced such a description, and the engineer gains their contempt instead of respect.

An invitation to bid upon a complete pumping plant without telling distances between boilers and pumps, or giving drawings showing their relative positions, leaves each bidder to supply what ought to have been given them exactly, or to bid upon a stand pipe which has only a definite description of diameter and height, leaves each bidder to supply a set of specifications of thicknesses with varying factors of safety.

A fair comparison of bids can hardly be made from such specifications, and the engineer who made them merits the contempt which both his employers and contractors heap upon him.

"Any extra work required under this contract shall be executed as directed by the chief engineer, and shall be paid for at a price fixed by him, which shall be final and conclusive."

The above expression is often met in specifications, and to say the least is a one-sided bargain.

If the engineer is known to the contractor, and his fairness established, the matter is not so uncertain; but in the present day of competition, it is no unusual thing to find contractors traveling from one thousand to two thousand miles to bid upon work, and it is then impossible to know what to expect from an engineer who is an entire stranger to them, and compensation for extra work ought to be stated in a more definite and certain manner.

Customs of workmen, such as brick and stone masons, plasterers, painters, etc., in measuring work differ materially in different localities and the method of work should be accurately described. For instance, if a man makes a bid calculating that 128 cubic feet make a cord of stone, and then when he comes to do the work finds that all local contractors and masons figure 100 cubic feet in a cord, with all corners figured twice, he furnishes 28 cubic feet for nothing.

There is an effort being made by many engineers to reduce *such* work to a uniform practice of measuring such work by

the cubic yard, actual measurement, and do away with the senseless customs used by workmen, which differ even in the same state, but the knowledge of this reform has not reached all parts of the country yet, as many recent sets of specifications will testify.

In short, if an engineer will constantly keep before him the *quality* and *quantity* of the work, his specifications will be such that contractors can figure intelligently, and will avoid future misunderstandings and litigation.

It is not always possible to give an exact statement of the gross amount of material to be used in the work. It can be approximated near enough for practical purposes, but the unit of measurement should be accurately defined.

The quality of the work can always be described in such certain language that no one can mistake its meaning, and a man who cannot do so is not worthy to be classed among engineers.

THE PRESIDENT: It is very certain that a man who has occasion to consult specifications for public works comes across some very queer specimens.

MR. SELLERS: I would like some of you gentlemen to call at my office. We have some specifications prepared by Mr. LaRue and myself, that I think cover this ground entirely.

MR. GRANVILLE: Measurements ought to be put in cubic yards. The difficulty is in measuring masonry where there are openings, and there will always be difficulty in settling with contractors, unless these matters are put into specifications. It is a matter that requires a great deal of care, but as a unit of measurement, we should not think of anything but a cubic yard. There is one extreme that engineers are likely to run into, and that is to tie the contractor down so tight that there is no chance for him at all. I have seen specifications so severe, that it would be impossible, in nine cases out of ten, for any contractor to comply with them. To be sure, there is opportunity given to the engineer to let up, but that is an objectionable feature. Nothing should be left simply to the judgment of the engineer, unless it is something that cannot be

foreseen. Circumstances are liable to arise in the execution of any important work that cannot be provided for, but where it is possible, it should be done in the specifications. But they should not attempt to be so severe with the contractor that he cannot carry out the specifications, as they are liable to drive away honest men.

MR. APPLETON: That is a good point. There is too much in many specifications—more than anybody has any idea of carrying out. If a contractor figures on carrying out a contract to the letter, he can never compete with others who do not expect to carry out the little points. My idea is to put what is absolutely necessary in the specifications, and leave out that part which you do not intend to enforce.

THE PRESIDENT: By attempting to put in too much, you are very apt to compel men, who intend to be honest in their bids, to put on a good deal higher price than they are really willing to do the work for.

MR. GRANVILLE: Of course, sometimes, if you happen to know the engineer, you are all right, but you have the advantage of some other man who doesn't know the engineer. I mean by that if you know the habits of the engineer, and his custom in enforcing his specifications, you have the advantage of the stranger.

THE PRESIDENT: And there is a great difference in engineers—in their judgment in the enforcement of specifications. Some men will insist on the exact performance of the specifications when the thing is almost impossible, while an old, experienced engineer, who has had a great deal of that kind of thing to do, will know when to require exactitude and when not to.

METHODS IN VILLAGE AND CEMETERY SURVEYING.

F. L. CHURCH.

Doubtless all who have had experience in surveying village and cemetery plats know the difficulty of getting measures on parallel lines to agree, particularly when the ground is uneven or obstructed to any extent, as it usually is in standing timber. We are also well aware that it is impracticable to run successive lines with a compass that will be exactly parallel without correcting them. If the work must be done with a compass, then lines should be measured and stakes set on opposite sides of the plat, and lines opened and corrected between these stakes, before the staking is done. But I think that an instrument that will measure angles is, if not indispensable, at least very desirable, and any surveyor who wishes to do this kind of work should provide himself with one. The methods that I wish to mention were worked out with a Gurley Reconnaissance Transit, trying to overcome the difficulties I have mentioned.

While I do not claim that they are better than any other, I have found them useful to me.

Of course the first thing to ascertain, is the plan of the plat, and if the adjoining sides are not at right angles, then the side to which the lots are to be squared must be decided upon. I have known of plats being laid out with adjacent sides of all lots not at right angles, but it seems to me that this is a very undesirable plan; still it is a point to be decided by the proprietor rather than the surveyor. Then if the land is tolerably level, measure either at right angles with or parallel to the guiding line, carefully set a row of stakes, marking the exact point with a tack, measuring and sighting again after the stake has been driven solid. Sometimes it takes considerable explanation to make the "hands" comprehend your plan, though if they are men of usual intelligence, they will learn it in a short time. That is one way in which land surveyors are

at a disadvantage with railway surveyors, because they must get along with untrained men in most cases, and by the time the men begin to know how to do the work well, as you want it done, the job is finished; and for the next, a new set of men have to be got along with. This makes it necessary to watch the work for errors and to check measures in every way possible. At one time after telling my men what to do, so I thought they understood, instead of measuring and lining on top of the stake for the position of the tack, they drove the tack in top of the stake, and then set the color pole on the tack, and if it was not right, tried to move the stake to get it right, which is a troublesome thing to do. This row of stakes being set correctly, select a line at right angles with it, which will give the best ground to measure on and set and mark stakes in the same way. These two lines of stakes will be the frame work of the plat. It will usually save labor to set stakes while running in the direction in which they stand closest together, that across the ends of the lots.

Having decided which way you will run while measuring, put sight pickets at each end of the base line which is at right angles to the lines you will run, and at all needed points, to have one or more in sight from every stake on the base line; being careful to get them set firmly and exactly right. This is best attended to when running the line; commencing at one end of the plat, set the transit over one of the tack-marked stakes, ranging it by the pickets, and then turn the telescope 90° and open and measure the line. Except the first few stakes, set the stakes lightly, so that they may be moved if they need it, to correct the measure.

A good way to measure, is to have one of the chainmen set the marking pins where stakes are to be set and let the stake driver follow with the stakes, but not move a pin until the next one is set, so as to measnre from a pin and not from a stake. Proceed in this manner until the stakes are set.

Now, to correct these stakes, place pickets on the base line parallel with lines to be corrected the same as on the first base line. Then set on this base line, as before on the other, and then turn 90° and sight through to each stake, thus crossing

the lines run before, and move each one that needs it, to make it agree with the measures on the base line. It probably will not be necessary to cross-sight every row of stakes, but one in three, or the more important ones if the plat is in timber will answer, and save work; as one or two may be measured to, and corrected each way from those that are sighted. If the lots in different parts of the plat lie in different directions, each part would have to be worked as though it was an independent plat. Different sized lots would make more base lines necessary.

Sometimes on account of rough or hilly ground, better results will be obtained by making one line a base line part way, and another the rest.

To illustrate my meaning, I will give an example: The northwest corner of a plat I surveyed was at the foot of a hill facing west, and it was steep enough to make a correct measure difficult. Along the west boundary it was nearly level and the hill turned to the east, so that on the south part of the plat a level line was obtained long enough to reach as far east as the top of the hill on the north side of the plat, so I corrected the west end from measures on the south side of the plat and then ran a line at right angles up on top and across the hill, and corrected the east end from a base line near the north side. The stakes were set running east and west.

Another plat had a bold hill projecting into it from the east, and in order to get a correct measure of the east boundary as well as correct location of two rows of stakes over the hill, I ran a line west parallel with the south boundary, then went north with the east boundary until I got north of the hill, then ran back parallel with the south boundary, and am satisfied that I got better results than I could have got by measuring over it. On hilly and rough ground there will often be a chance for the exercise of judgment in deciding where to locate base lines, and no rule can be given, except to make measures to correct from, carefully, on the best ground you have, and start all measures from lines which are as correct as you can get them. The angles of the boundary must be correctly measured, and the stakes on or next to either of them and not parallel with either base line can still be run from the

intersecting base and corrected from the other, by knowing the angle. If lots are not right angled, but have their sides parallel to one boundary and their ends to the other, the same plan can be used by turning the proper angle instead of 90°. It will help to avoid mistakes in turning angles to always keep the limb so that the vernier reads 0 with the telescope directed along the same line, or direction, say the one running nearest north, then note the reading on the limb when turned in the direction of each line of the plat.

The same method may be used in cemetery work to good advantage when quite a number of lots are laid out of the same size. In curve and irregular work the bearings may still be taken by angles from lines, the direction of which is known, taking care to have a sufficient number of hubs or turning points on all lines likely to be used for this purpose, as well as at all points where lines in different directions start, to be able to get the direction of the line wherever it is needed. It will be seen that the object is to get the lines correct in direction without correcting them, which may be done within narrow limits by angles from lines the direction of which is known, if care is taken; and to make all measures agree with those that are presumably the best.

I wish to make a query in regard to the location of monuments. Though it is not covered by the title of my paper, it is closely related with it. Where is the best place to put the monuments for the intersection of streets or streets and alleys? If they are put at the intersection of side lines, that is, at lot corners, they are in the way of fences; if put in at the center intersection they are handy to work from, but are apt to be disturbed in making and working the street, and if the streets are ever made good will be destroyed, or be badly in the way. I have set some both ways and do not like either. I think now that a good way is to set them four or five feet from the lot corner. I have set some in this way putting them in line one way with the stakes and four or five out in the street the other way; at alleys I put them in the center of the alley.

I should like to know the opinion and practice of others.

My purpose in writing this has been as much to find out

the methods of others as to give my own, as I have never seen any description of methods for this purpose, and if I can get anything better I should like to do so.

METHODS EMPLOYED IN LAYING OUT A TOWN PLAT.

BY A. J. TEED.

During the past summer I have had occasion to survey and plat into town lots a tract of about 300 acres. Some of the methods employed in doing the work may be of interest to surveyors, even if they are not new or instructive.

The land was nearly level and while covered with stumps and logs, there were no more trees or bushes to obstruct the line of sight than could be removed. I could get in all cases, an unobstructed view, and on some of the boundaries there was a good place to measure, so there was no reason why accurate work could not be done.

As the land was likely to become valuable, I determined to forstall the future profits of lawyers, accruing from litigation that should arise over my mistakes, by doing accurate work.

The land was bounded on the north by a level and well cleaned wagon road, and was traversed by three straight railroad lines. These roads afforded an excellent place to measure, but the east and west quarter line, the west section line, and the west boundary of the plat must be measured over stumps and logs. To make the measurements on these lines agree exactly with those on the railroad was the task I undertook to accomplish.

Owing to the right of property owners, it was necessary to make the streets conform to the government survey. As the government surveyors did not use a transit and steel tape in their survey of this section, the angles were not right angles, and the lines were not straight. In fact, there is not a single right angle in the entire plat. Those angles that appear to be right angles, vary from 3 to 18′.

I ignored the eighth lines and made all east and west streets parallel with the east and west quarter line, and all north and south streets parallel with the north and south section line. As the plat is partly in two sections, this made a small angle in each street as they cross the section and quarter lines.

The method employed in the survey was to work from the outside in, from the great to the small. The boundaries were first established, and then the interior street lines were run, setting monuments at their intersections. The blocks were then subdivided into lots.

A brother surveyor once remarked to me: "That he knew of some men just mean enough to kick, if a surveyor varied a foot in the boundary of a lot." In this plat I believe that there is not a single block the boundaries of which vary more than one inch from what they were intended to be, and as each block line is again sub-divided into from 6 to 8 parts, I believe that the greatest average variation of any one lot will not exceed one-fourth inch, and generally, it will not exceed one-eight to one-sixteenth of an inch from the size it was intended to be.

If it takes a mean man to kick on the variation of one foot in the size of a lot, the exact amount of meanness a man must possess to kick on this survey can be mathematically calculated by the principle of general average.

The transit used in this survey I put in perfect adjustment, so far as the line of collimation is concerned, but I did not have confidence in its ability to measure an angle to less than 1′. But in all the principal angles I took at least four independent observations, as the sum of all the external angles in the principal triangles over quadrilaterals equaled four right angles to within less than 1′. I feel confident that I have all the angles correct to within less than ½′.

The labor of making the measurements was facilitated by the presence of the three railroads that crossed the plat. The east and west quarter line had to be measured on the natural ground. I measured the line three times and the greatest variation was 1½ inches in one-quarter mile.

To get the correct distance between the streets on the

north and south lines, I carefully measured the angles of the two north and south railroads from the north and south streets, and multiplied the secant of these angles by the distance between the streets, and laid that distance off on the railroad and put in points.

At first I thought that a variation of a few minutes in the angles of the railroads would make no perceptible difference in the length of the secants, but I found that to make the distance on each railroad from where they cross the quarter line to their intersection agree, the angles must be exact. That a a variation in the angle of the Cummer railroad of 2′ would vitiate the entire survey.

Having established the points for the intersecting streets on these two railroads to my satisfaction, I proceeded to measure the west section line. The ground here not being so regular, it was more difficult to get an accurate measurement. After measuring the line carefully as I could, I found it necessary to add nearly one inch to each block of 366 feet, to make the entire line agree with the calculated distance as determined by the measurements on the railroads.

Having established points on the two railroads, and on the section line, I set the transit over each point on the Cummer railroad and back-sighted to a flag held on the G. R. & I. railroad, and then ahead to a flag at the corresponding point on the section line. In every case I found the line practically straight.

Assuming that to be correct, all intermediate points were lined in, independently of the chaining.

The point on the north and south streets were set by sighting from the north boundary to the quarter line, and from the quarter line to points on the T. & A. A., set in the same manner as those on the north and south railroads.

As I had on this survey most of the time only one man to assist me, all the intermediate street lines were chained; but no attempt was made to do the work accurately, and the lining was all done with the eye.

It is an easy matter to thus set points 300 or 400 feet apart, that will not be more than three or four inches out of place,

but to set them so that they will not vary more than one-half inch by the chain alone, is a very difficult operation. The intermediate points thus set by the chain, which were approximately correct, were then lined in with the transit.

During the progress of the survey, the intersecting points were marked by small pegs, about one inch square, and points marked on them by means of tacks. By using small pegs, a man can carry enough for a line a half mile long in his coat pocket, or tied up with a string, without being a burden to him; thus saving the expense of an extra man to carry stakes, besides, small stakes can be inserted in the ground more quickly and more accurately than large ones. After these points had all been established, they were replaced by pieces of gas pipe three to five feet long.

In order to get the gas pipe in the right position, I used a stick about three feet long with a little notch cut in the middle, and one near each end. The middle notch was laid exactly over the tack, and a pin inserted in the ground in the notch at each end. The stick being removed, the gas pipes were then driven in the hole where the peg stood, nearly to the surface of the ground; the stick was then replaced and the pipe was wedged over to the exact position and driven out of sight.

In this plat, the north and south streets all make an angle of 8′ on the quarter line, and the east and west streets make an angle of 18′ on the section line. To test the accuracy of the chaining this angle of deflection was measured on each street, and when it did not read the same, the error was discovered and corrected, so that on the entire plat the work of the tape was everywhere checked by the transit, and the work of the transit was checked by the tape. Perhaps the most interesting part of this surveying was my experience with tapes.

I used on this survey a tape obtained from Justus Roe, in connection with an old Hodgman tape, which I had adjusted to a standard tape which I had had for fifteen years. The Roe tape was just a quarter inch shorter in a 100 than my standard.

In using the Roe tape I attempted to make the work agree with my old tape, by adding one quarter inch per 100 to each

line measured. But upon trial I found that this was not enough. Measuring one-half mile along the level grade of a railroad track, the best place in the world to measure, after allowing the quarter inch per 100, the Roe tape was still too short. I can account for this difference only by the different methods in which the pins are set. In my old tape the distances are taken from a line on the tape held to the *center* of the pin. In the Roe tape the distances are taken from the *front* side of the pin.

Theoretically, these methods ought to give the same results, but the two tapes would not measure the same, and I found the difference to be about one quarter inch in 400 feet.

This difference however, is comparatively small, and might, I suppose, be eliminated by more care in setting the pins, But which of these two tapes is correct, as to its recorded length?

My old tape I obtained from Hodgman, but as I found it one-half inch too short, I regraduated it to agree with my standard. This standard I obtained from Gurley and have compared it with a number of good tapes, and believe it to be right. Recently I compared tapes with the engineers of one of our railroads, and his tape did not agree with any of mine. Now which of these four tapes is right? My Gurly tape is warranted to be correct according to the U. S. Survey thereof.

The Hodgman tape is made from a steel rod furnished by the Government, and is absolutely correct.

The Roe tape I returned, because it was too short, and they write me that they have compared it with the U. S. standard, in the coast survey office of the city of New York, and it is exactly correct.

The railroad engineer's tape has been tested by the Supreme Court and must be right.

Here are four tapes, each one warranted to be correct by the U. S. standard, and yet each one is different. The greatest difference being one-half inch; the Gurley tape being the longest, and the Hodgman tape the shortest. It seems to me that there are about as many U. S. standards as there are

MR. HODGMAN: A few years ago I took occasion to write to the civil engineers of nearly all the leading cities of the United States, asking them the question as to what kind of monuments they used, and where they were placed. The result was a very motley set of returns, which showed that very few of the leading cities had any monuments worthy the name. We found some of them set their monuments on the angles outside of the street, at the margin, right on the corner lot, some in the middle of the street, and some of them set them on some arbitrary line—some line, neither the centre of the street nor the side line. I made up my mind that the best place of all, even supposing they are liable to be disturbed, is the center line of the street, and make enough observations to permanent objects near by, so we can re-locate the point.

MR. HUBBELL: That is the best place undoubtedly, until you begin to put sewers into the street.

MR. HODGMAN: Of course that is the trouble—their being destroyed, but as I said, I would take enough references to permanent points, and then I would make it a punishable offence to disturb them without the authority of the engineer, and see that they were punished if they did it.

THE PRESIDENT: And to do that, you would have to make one man judge, jury and executioner, otherwise you couldn't do it. In Manistee there was a time when there were a great many good monuments, and not half of them can be found now. They were almost all left, and pretty well taken care of until we began to put sewers in. I supposed the location of them, as Mr. Hubbell says, was arbitrarily settled by law; that they had to be at the intersections of streets and alleys.

MR. HUBBELL: I wrote to the Auditor-General in regard to that point, and he says that any of those points, if uniform throughout the plat, will be accepted at their office as correct. I [illegible] some at the lot corners, some on center intersec- [illegible] some four feet from lot corners, and all were

[illegible]MAN: What do you use for monuments?

[illegible] used gas pipe considerably, and I [illegible]t or more long.

political parties. The democrats and republicans on the extreme, and the prohibitionists and the peoples party waging between. If there is a member of this society who has a tape which he knows to be correct, I would like to obtain his photograph, not of his tape, but of the man; for I am tired of looking at absolutely correct tapes.

THE PRESIDENT: Gentlemen, these papers are before you for any discussion. If anybody thinks it is easy to lay off a large piece of land, and come right every time, he will find it easier than I ever did.

MR. BEAN: If they can make the second measure come out like the first, they can do better than I can.

MR. HODGMAN: My general method has been pretty much the same as Mr. Church's. I have a son who has worked with me ever since he was old enough to carry a pole in his hand, until he left me for a better job. After having laid out these base lines, I have run the interior lines and set the stakes without measuring at all, by sighting both ways—with his assistance—and all the interior work was done by sighting both ways. I stand on one line and sight toward a picket on the opposite side of the block; my son stands on the other line crossing it and sights to a picket the other way, and the rodman stands with a rod held plumb, moving it as we direct, until it is exactly in line both ways. All the stakes are rapidly placed in line both ways without measuring any but the outside row.

THE PRESIDENT: That will answer very well where the ground is perfectly clear of timber, but suppose you are in an old pinery ground covered with logs and blackberry brush?

MR. HODGMAN: Do the best you can then.

MR. HUBBELL: I have had a little experience on rough land, and have tried Mr. Hodgman's plan, and found it very satisfactory, especially over rough land. I have often used two instruments, having a man who was capable of using one himself. As for monuments, I had supposed that the centre line of streets and alleys was the proper place. I have used a ¾″ iron rod, driving it to the surface of the ground, and then witnessing it by some temporary post or stick, that would indicate the approximate neighborhood.

MR. HODGMAN: A few years ago I took occasion to write to the civil engineers of nearly all the leading cities of the United States, asking them the question as to what kind of monuments they used, and where they were placed. The result was a very motley set of returns, which showed that very few of the leading cities had any monuments worthy the name. We found some of them set their monuments on the angles outside of the street, at the margin, right on the corner lot, some in the middle of the street, and some of them set them on some arbitrary line—some line, neither the centre of the street nor the side line. I made up my mind that the best place of all, even supposing they are liable to be disturbed, is the center line of the street, and make enough observations to permanent objects near by, so we can re-locate the point.

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MR. HODGMAN: What do you use for monuments?

MR. HUBBELL: I have used gas pipe considerably, and I have used cedar posts, a foot or more long.

MR. ALBERTSON: I was a little surprised in looking at the plats in the Auditor-General's office, to see that one of the permanent monuments consisted of an oak stake 1½ inches square and 15 inches long. That might be serviceable in a town with a junk shop!

MR. HODGMAN: We want for a monument something that is not liable to be destroyed by the boys. There is a post that is made by a Jackson company, but it has to be protected because it is readily broken. A good wooden stake well driven is a more permanent monument than a wrought iron rod or gas pipe. The stakes, although they rot away, will yet, if they are driven below the surface dirt, last indefinitely. I have dug them up where they had been down for sixty years. The rotten wood is just as good a mark of the location as the sound wood is, and in some localities it will last an unknown length of time.

MR. SELLERS: This summer I platted a sub-division. At the corners I placed stakes four inches square and two feet long; the intervening lot stakes were 18 inches long, and no questions were asked as to what they were or where they were placed.

MR. VINCENT: When they come to build fences, what becomes of those corner stakes?

MR. SELLERS: The corner stakes are more liable to destruction than the center lines. You may take the greatest pains, and the first thing they do is to dig them out.

MR. VINCENT: I don't think you are troubled with fire, as we in the north are, in Copemish and towns of that kind. The wooden stakes only last until a man clears off his lot, and half of the time his lot is cleared by fire.

MR. HODGMAN: In our part of the state, the fire only burns the top of the stake off.

MR. VINCENT: Yes, but there are a good many stakes driven around, and every summer the fire burns off the top of them and the finding of one wooden stake isn't very satisfactory evidence to me. I am surprised that our Auditor-General takes plats without something beside wooden stakes. I have taken a great deal of pains. The last village I platted, it took

109 to mark the intersection of streets and alleys, and it took a great deal of iron, and I am glad to know that we can use wooden pegs; it simplifies matters. But by using iron stakes, if one is gone you can find the others, and I, myself, should be very loath to give them up. I find that up in the northern towns, after they get their lots cleared off, the wooden stakes are pretty scarce. They burn off and are raked off. It is different in cleared land, but I should insist on something more than wooden stakes in a village plat. For the corners of boundaries I have used gas pipe two feet long, or buried a beer bottle, or something of that kind, and I have found it a pretty good way to put a corner down deep, at least three feet down; make a post hole and let your plumb locate that nicely, and then take ordinary bricks and make a little pier to the surface. They will plow up two or three, but some will remain.

MR. STRONG: Speaking of a wooden stake, and its being a proper monument, I wish to say that I was up in the Auditor's office, and that the first two plats in the last book are from Detroit, and the monuments used were oak stakes, 1¼ inches in diameter. I asked the Auditor if such stakes would answer the purpose of the law, and he said the carrying out of this law depended upon the honesty of the surveyor. I said something further, about witnessing these monuments. I don't know as I ought to say it here, because many of us do not witness the monuments we ought to, and where we do, they are written down in the note books, and not on the plat. The law says that we shall monument all of these corners at the ends of the streets and alleys; it says furthermore, they shall be witnessed by permanent objects. The words are: "They shall be witnessed," but if you have witnessed them where is the place to show it, if not on that plat. Now it may be that 1¼ inch stake is a monument, and then maybe it is not. So far as I am concerned, I have no desire to put in a 1¼ inch stake, and certify to its being a monument, and I think we ought to carry out this law in respect to witnesses. The day is coming when there will be some men in this office that will say to these engineers, have you witnessed these monuments? "Yes, got it in my note book." Does that answer the purpose of the

law? We know better. Now it is time, if it is necessary to have our witnesses written in the plat, that we should know it, and begin early enough so we won't be dead and gone before a start is made.

MR. CHURCH: The difficulty in the way of the plan the gentleman has spoken of, is that most places where there are trees that can be marked as witnesses, they are usually soon cleared off. If it was an old place where you had the assurance that the trees would be left, I think it would be a very good plan, but I myself, have never surveyed a plat yet, where there was an assurance that a single tree would remain.

MR. BEAN: This question of monuments is a very essential one. There is a way of putting in wooden stakes that will answer very well. Take an ordinary stake, prepare your hole and fill it full of lime; then put in your stake and you have a pretty good monument. If they take the stake out, they will have to take out all of the lime at the bottom of the pit before they can destroy the position of that stake. Speaking about iron stakes, I notice that most of those here have mentioned gas pipe. If you are going to put in iron, cast iron is away ahead of wrought iron; cast iron water pipe has been laid for 100 years in New York city, and upon examination they could notice but very little depreciation in its value, but an ordinary gas pipe will rust out in a very short time.

Now, in regard to position of stakes—the centre or sides of the street. I have used both methods; another method I have adopted, is to put the stake out perhaps two feet from the corner intersection, and bore a hole six feet deep and put in lime or pulverized brick. If you put the stake at the corner, the first man that builds his fence will be very certain to dig that post out, and when you come around, he will tell you that the corner post is the exact point—he has taken pains to observe that point. But if you will set your monument in the street 18 inches, you will probably clear his post, and more especially if you fill the hole up with lime.

Another thing in regard to witnesses. Of course it is a hard matter to make witnesses of plats at the corners. If you had for instance, good permanent buildings, or where you were

taking measurements to the base of these walls, you would have something that would last. I would like the Society's opinion in regard to taking witness trees in the country. What is the preferable timber to use for witness trees? My experience has been, that a large hickory tree is the best, although when I was in the Government Survey, we were allowed to take anything except a hickory tree, even a poplar. True, the hickory is a short lived tree, but how about determining the position of that tree by a tap root. I have been surveying in Jackson county for a long time, and I think I have never failed in determining a corner to my satisfaction when I had a large hickory. When I examined my notes and found a good hickory for a witness, I found I could establish my corner.

MR. GOODALE: It seem to me if we place our monuments 18 inches or four feet from the block corner, that it is going to be right under the sidewalk. In my practice I have used the centre of the street mostly. I think by planting them well, they will be less disturbed there until the catch basins are put in.

MR. BEAN: I would say in connection with that—that would be where I would like to look for them. There are corners in Jackson which I would give $100 to locate. If I could locate them by taking up a block walk I would do it in a minute,

MR. DOANE: I have found the most satisfaction by securing the boundaries, and then I know where to go to work. I platted an 80 acres a few years ago and I got all of the boundaries. It was entirely covered by woods. I measured the boundaries very carefully, and then I knew exactly how far it would be across by computation, and then when I came to measure across by short lines, I found out if the measurement corresponded. In some places I put in iron stakes at the centre of intersection and others at the corners of the streets. I like to put them in at both places. Of course where you are in the woods, wooden stakes are very apt to to burn out, and you must have something that fire will not destroy, and still you usually find Government stakes that are not burned out,—if they are not decayed.

One objection to setting the post 18 inches or two feet from where it belongs, is that they are very apt to use that as a corner, unless you put the monument down as deep as Mr. Bean has suggested. I found such a case in surveying a section. It had been surveyed in 1877, re-surveyed, and they planted a corner two rods east of the true corner, for a witness corner and witnessed to that. The country was partly settled up at that time, and they went on and used that as the true corner; I was called to establish that corner a few days ago, and I found that in dividing it up, it brought that corner about two rods east of the point equi-distant, and it had been used probably for eighteen or twenty years as the true corner, there was a high-way built a mile north and south, and all the conveyances went to that corner, the gentlemen on the east was very anxious I should place that corner equi-distant between the section corners. I hardly felt as I wanted the responsibility of bringing on a law suit, so I told him I thought the true corner stone might be two rods west, and if he wanted to secure legal advice and go to law about it, I should not try to hinder him, butI shouldn't set the corner two rods west of there and pretend to say he could hold to it.

MR. BEAN: I would put these corners for permanent monuments only for blocks, two corners for each one, boring down about six feet, and these monuments I would put below the surface and leave a stake at the proper corner. If you could establish your block without any difficulty, there is no trouble then in making your lot corners; it is a little objectionable to have them under the sidewalk, but it is a pretty safe place.

MR. DOANE: In Gladwin, they have put their sidewalks all six feet from the street line, and left the space between for planting trees, and it makes a very pretty appearance, and would not disturb the monuments, although it makes the street a little narrow. That is the way their entire village sidewalks are laid out with the exception of the main streets; their sidewalks are six feet wide and on the main streets they are 12 feet wide.

MR. HUBBELL: I get the exterior boundaries and measure

them carefully; at those corners I put good monuments, and those corners I witness with trees if I can get them, and these witness trees I record on the plat. The interior work, I do not attempt to witness, this intersection of street corners. If I can find the outer lines, I can find the inside.

MR. VINCENT: Mr. Bean spoke of a hole, and filling it with lime. Now that may do very well in a clay country, where the hole will keep its form, but in our sandy country, and by the time the old surveyor had dug down two or three times, and the new surveyor five or six times, I think it would be very distracting.

MR. SKEELS: I think the best spot for a monument is right where it belongs. Find that place and put it there, whether under the sidewalk, in the centre of the street, or wherever it may be, and the best corner I have ever used or seen was to to take a post-auger, with a handle six feet long, and with it bore a hole; then take our common brick, and put one at the bottom and fill around it; lay another across and another on top of that, and fill in around them. In scraping or plowing, you disturb but one brick,—the others are there.

A party came into the office one day and wanted I should set some iron stakes at the corner of his lots. He would furnish the stakes. He said he wanted to put a nut on the upper end of the stake. I told him to put the nut so there would be 1½ inches of the stake through the nut, and put that end in the ground. He asked the reason, and I told him, and we set the corners in that way, and they have never been pulled up. Travelling through Richmond, Indiana, I noticed on the corner where the cement sidewalks were built, and within the stone flagging at the corner of the street was a stone about three inches square, with a cross in it. I noticed it and made up my mind it was the corner of the block. I travelled around a mile or so, and at each block corner, if it was a stone walk, there had been a hole cut through the stone, and that cross was there. If it was a cement walk, it was there; and if it was a board walk, that stone came up just flush with the walk, with that cross on. That was a good plan. Anything that we can get, and have it durable, will answer.

So long as the timber is standing it is all right, and it shows the disposition of the operator to do his work and do it well, if he uses them for witnesses, but it is of short duration. The proper thing is a good monument in the right place.

MR. HODGMAN: The brick plan is pretty good, so far as its durability is concerned. The failing is that it is not sufficiently definite, even if you have got a whole brick there. In the outset, where a few inches does not amount to much, that is all right, but if it is in the city of Grand Rapids or Detroit, we want measurements more definite than the brick. I think, practically, as Mr. Skeels said a year ago, this whole question is fully treated in my Manual. I have restored, in the past few years, something like 2,000 government corners, and have used, almost entirely, the monuments made by the Jackson Fire Clay Co. I bore a hole three or four feet deep and put one above another, packing around them with the best material I can get. These monuments have the advantage that they have a cross marked on the top of them, and you can locate the exact point as long as they stay there; and they have the advantage of the brick, in that, if the top gets knocked off, there are more below to mark the place. If there is anything more desirable, I should like to know it.

I think Mr. Bean is right about the hickory trees. I have had lots of experience in hunting witness trees and corners. I guess Mr. Bean and I have done more of that work than any other two men in Michigan. I find that white oak is pretty good, too. They have tap roots that give you a pointer to tell where to go for your stake.

MR. BEAN: One suggestion in reference to taking out a stake from a place where you have any lime. Now, there is the great trouble,—about 99 men in 100 do not know how to use a shovel around the corner. They will obliterate the whole thing in about five minutes. Now, supposing you have a hole here and put in two inches of lime, six feet deep. I would ask the gentlemen if it is necessary to dig all that out in order to know it is lime. Just the moment you come to the lime, that is all there is of it. You put a stone in the centre of a street or a country road, and the first man that is at work on

the road will hook a plow on it and pull it out, but the lime he will remove just the depth of the plowing. You can identify the corner, too, just as well, by following down where the stake has polished a way, as though the stake stood there, but if you go and take the ground up two or three feet deep, the game is up.

MR. HODGMAN: Now, if I were going to put in lime, I would use the best Portland cement. The lime itself is soluble in water, and dissolves in a short time—that is, common quick lime. If I were going to put it in, I would use a hydraulic lime, or any substance that is durable and can be put in in that way.

MR. APPLETON: When we came in, Mr. Chairman, they were talking about the proper place, the centre of the street, the corner of the block. Right in this town, to my knowledge, more monuments have been destroyed that were situated in the middle of the street, since the improvements have been going on there, than anywhere else you could speak of. Of course, if it is a section corner or something of that kind, there is the place for it, but if it simply marks an intersection or the corner of a block, it seems to me you could hardly set it in a poorer place than the centre of the street. Down in the lower end of this town there is one monument that governs the whole of North Lansing. I was City Engineer at the time and was very careful to preserve it. When we put a sewer down there, I measured very accurately and restored the place; I could not do otherwise, because the records called for a monument there, but there was quicksand where the sewer was put in, and the entire thing fell in, monument and all. The same thing happened again, and now I don't believe there is a man who can go and restore that monument within ten square feet. I found a piece of iron there, and notwithstanding I begged and prayed the contractor to let that monument alone, blessed if he didn't pull it out. I think the witnesses called for 90 links from the door of a blacksmith shop, and the blacksmith shop was burned down twenty years ago. Of course, it is all right enough to put things in the centre of the street, but, if you can, put them at the corner of the block.

MR. HODGMAN: It may not be out of place to describe the manner in which the monuments in Kalamazoo are located. A stone monument is placed at the centre intersection; in a little pit, and around that pit is an iron casting, I think it is a casting such as is used for a lamp hole, and then that is covered with a conical cast iron cover that comes up flush with the pavement. For some purposes, the simple cover answers,—if you want to be more exact, lift the cover. I think there is very little danger of any of these monuments ever being disturbed.

MR. APPLETON: There is a class of people that seem to delight in disturbing monuments.

MR. HODGMAN: I guess you cannot put in any monument that cannot be taken out, or that won't be taken out in some instances, but on the whole, I think the centre of the street is as little liable to be disturbed as any.

MR. SKEELS: So far as that is concerned, there is just as much liability to destroy a monument at the corner of a block as at the centre of the street. We that have been interested in excavations for buildings know this. You get your area wall out nine to fourteen feet from the corner of the block proper, and there is no way of perpetuating it only by the block itself, and you can't do it any other way, only to do it, and take care of it after it is done.

MR. HODGMAN: Referring to standards of measure, I think it is just exactly as Mr. Teed has said, there are a great many standards that are sent out; and all are guaranteed to be United States standards, yet they do not agree among themselves.

MR. ROGERS: It has been suggested that it would be a good thing if we had a standard in Lansing, then we could test them and have a uniform standard among ourselves.

MR. WILLIAMS: How many acres were there surveyed?

MR. TEED. About three hundred, part of it was included in the frame-work, but I have not charged for that yet.

MR. CHURCH: Can you put that on a plat in this state? The law says the paper must be 18 by 24 inches; can you get that on it?

MR. TEED: The bill sent in for the stakes was for 2250; there are over 1000 lots in the business there.

THE PRESIDENT: Mr. Church asks how you managed to get that plat on the paper of the size required by the statute?

MR. TEED: I did not put it on; in the first place, it is not done yet. The survey was made, but the plat is not finished; but when I finish, I will put on all the sheet holds, and put the rest on another sheet.

MR. ROGERS: I can answer Mr. Church's question; I had occasion to plat 800 acres into 500 lots, and the plat is in four parts, number 1, 2, 3, 4, and one sheet is given entirely to the description making five sheets in all; 15 pieces of paper in a set of three plats. That is on record now, here at the Auditor General's office. I also have another one of two pieces.

MR. SKEELS: There are certain cases where Auditor General's condemn that; the certificate has to be attached in certain cases.

MR. HODGMAN: In regard to the question of tapes, Mr. Mr. Rogers suggested that we might have a standard here at Lansing, and then all be alike. There is a difference in the quality of steel. A difference in the manufacture of steel causes a different rate of expansion in the different kinds of tape; and so two tapes might compare exactly at a certain temperature and when the temperature changed, the tapes would be different.

TOWNSHIP BURYING GROUNDS; PLATS AND RECORDS.

D. J. ALBERTSON.

Before I wrote my paper, I thought there was no question in regard to the statute, regarding plats, and I wrote to the Auditor General. He was of the opinion that cemetery plats came under the general plat law. That was news to me, and I took some pains to look the matter up. I consulted two different attorneys in the matter, and they did not agree with the Auditor General, but could not give a decided opinion. I went this afternoon and called on the Attorney General and thought perhaps I could get an opinion from him. He was very courteous and devoted some time to the consideration, but his duties were pressing, and he did not have time enough to devote to the question, but he was of the opinion that the law regarding cemetery plats and the general plat law were independent. He did not say that those which were made under the provision of the law in regard to cemetery plats would not be good, but he thought that the statute was deficient in some ways, and he thought that the diagram of the land and description ought to be more complete, so that the lots could be located without any question as to where they were. He suggested that it would be well to have the law amended so that the plat that was filed at the Register's office would be made of record, and a certified copy could be used in courts of record. He thought that cemetery plats, made under the general plat law, would be good, but he was inclined to the opinion that the fee of lands so transferred would be vested in the purchaser and not remain in the Board of Health. After this introduction I will read the paper:

Mr. President and Gentlemen:

It is not the object of this paper to offer anything strikingly original, or to revolutionize cemetery platting; but to simply present a few observations and plans that the writer has found adapted to the requirements of the work.

The time has come in many townships where the burying grounds located in an early day have become entirely occupied, and measures are necessary for their enlargement, or the location of new cemeteries. These old yards exist in all manner of form and condition. Many were never originally staked out; burials were made promiscuously, and so remain to this day; others, in years past, came under the supervision of officers with "progressive" ideas, who caused the trumpet to blow the resurrection signal for that particular yard, arranged the graves in rows, platted the ground with greater or less accuracy, perhaps terraced the lots and arranged things after the flower-bed style of architecture. Even at this late day, there seems to be little more system than in the past.

A brief digest of part of the law relating to township burying grounds may not be out of place:

"In every surveyed township, the board of health shall procure sufficient grounds for burial purposes, and their successors hold the fee of such land in trust for said township. They may sell or dispose of the same, or any part thereof, at any time until the same shall have been occupied, then only by order of court upon proper petition. In case of the division of a township, the cemetery belongs to that part in which it is stuated. The board shall make all regulations necessary for the government of the same, and shall give notice of such regulations by publishing the same in some newspaper, if there be one in the township; if not, by posting the same in five public places. They shall keep the grounds properly fenced, and all cost incurred for purchasing, fencing, and regulating shall be certified by them to the township board, as part of the contingent expenses of the township. They may convey single or family burial lots in such township burying ground to such persons as may desire to procure the same, and use the proceeds towards improving the grounds, but must certify the amount of such sales and expenditures to the township board. *But*, before they can sell or convey any lots as above mentioned, they must cause the burying ground to be laid out in such form as they may choose, and cause two maps thereof to be made under the supervision and direction of the health officer and clerk, which shall be certified by them to be correct. One of said duplicate maps shall be filed in the office of the register of deeds of the county, and the other in office of the clerk of the board.

"Said maps shall describe the lands belonging to such bury-

ing ground, its boundaries and location. Also, show the lots or sub-divisions named, or numbered, with their size, situation and extent. Also, the width, extent and location of all streets, alleys or walks."

To this I would add: Plant permanent monuments at all angles and at all intersections of principal lines, walks or drives; and, if practicable, give angles at intersection. Mark *all* dimensions of irregular lots, blocks or pieces, and give enough dimensions on those of uniform size to leave no uncertainty as to their size. Draw the map to a true scale, give unit of same, and show the meridian. In fact, make the diagram of land and description to conform with those intended for city and village lots.

No rules or suggestions can be given as to the laying out. Each case must be governed by circumstances. Township burying grounds, usually, being square or rectangular, and in size varying from two to six hundred feet, afford but little opportunity for fancy styles. If an addition, many times the layout of the original part prevents systems that would otherwise be desirable.

In the matter of stakes, there seems to be a commendable inclination towards permanent stakes at lot corners. Wood stakes are unsightly and of short duration. Probably the best are the vitrified fire clay or terra cotta stake with the numbers stamped into the material while plastic. Cast-iron stakes are durable, but those having the cross section of an I beam, to facilitate painting the numbers on the front, are liable, in a short time, to present a zig-zag line, very unpleasant to the eye. A ⊢ cross section might obviate this. The smaller sizes of drain tile, with but a few inches projecting above the surface, are, I think, the cheapest and most permanent procurable. By setting every tenth one of a larger size, no numbering is necessary.

The law provides that "The board of health shall cause the grounds to be laid out," etc. A certificate, something like the following would seem necessary, and show that they had done so, by what authority, under what conditions, and that they approved of the proceedings.

"*Know all Men by these Presents:* That we, the undersigned, constituting the board of health [or majority of] of the Township of A——, have caused the land embraced in the annexed plat to be surveyed, laid out and platted, in accordance with section 1638, chapter 39 of Howell's Statutes, 3d volume, the same to be used as a township burying ground and known as ..... We hereby dedicate said ground for burial purposes, subject to the existing regulations and such others as may be made for the government of the same. We also accept and adopt said plat as hereon delineated.

[Signed officially.]

....., *Supervisor,*
....., *Township Clerk,*
....., *Justice of the Peace,*
....., *Justice of the Peace,*
Board of Health."

The law further provides that "The plat shall be made under the supervision and direction of the health officer and clerk," etc. The following certificate, or its equivalent, would therefore seem imperative:

"We, the undersigned, B—— C——, as health officer, and D—— E——, as township clerk of the township of A——, hereby certify that the plat hereon delineated has been prepared under our supervision and direction, and that the same is a true map of said burying ground.

....., *Health Officer,*
....., *Township Clerk.*

Dated this.....day of.....189.."

The law provides that duplicate maps shall be filed in the office of the register of deeds of the county, and township clerk's office, etc. Some certificate like the following, on each, would seem essential, and show that the other map had been filed as required.

"I hereby certify that a duplicate copy of this map of..... as compared by me, has been filed in my office.

[*Signed*]......"

A surveyor's certificate, something like the following, might be advisable, and show who made the survey, nature of permanent monuments, etc.:

"I hereby certify that the plat hereon delineated is a correct one, and that permanent monuments, consisting of (*State nature, size, material, etc.*), have been planted at points marked thus O, as hereon shown, at all angles in boundaries, and at all intersections of principal lines, walks or drives.

_____, *Surveyor.*"

It would be well to add, for the convenience of the recorders:

"Received and filed in my office at_____o'clock____M., this _____day of_____, 189__.

[*Signed by register of deeds or clerk.*]"

This closes the plat or record and location of lots, but affords no means of showing location of graves, or names of those interred. This is one of the most important parts of a cemetery record. It takes but a few short years for a grave to sink to the level of the surrounding surface. Quite recently a case came to the knowledge of the writer where a grave dug on supposed unoccupied territory unearthed the bones of a previous burial. There is, also, an inclination towards discarding raised mounds over the graves entirely.

One of the best records that has come to my knowledge is shown below, and comprises the desirable features of several records:

Burial Record of Evergreenwood Cemetery:

Date of Burial.			Full Name.	Male or Female.	Age.	No. of of Grave.	Place of Death.	Disease or Cause.	No. of Lot.	Remarks.
Mo.	Da.	Yr.								

In the column "No. of Grave" is inserted the number consecutive with the digging, reference being had to a diagram of the lot, not drawn to scale, for their relative positions, thus:

	3	1		2	4

or by dividing each lot into sections of an arbitrary size, and numbering them consecutively, thus:

1	2	3	4
8	7	6	5

giving to each grave the number of its section. This I would amend by giving to each grave the number corresponding to the number of feet the center line of grave was from a certain uniform point on each lot, as the right hand front corner, designating front and back tiers on square lots. The above meets most requirements of a *burial* record, but nothing further.

The following I have designed as embracing nearly everything required by way of reference or record.

EAST COOPER CEMETERY.

LOT No.----------

Conveyed to----------

Date----------

by----------

----------*Sexton.*

Heir's burial privileges acquired by

----------*heir of*----------

by----------

----------*Sexton.*

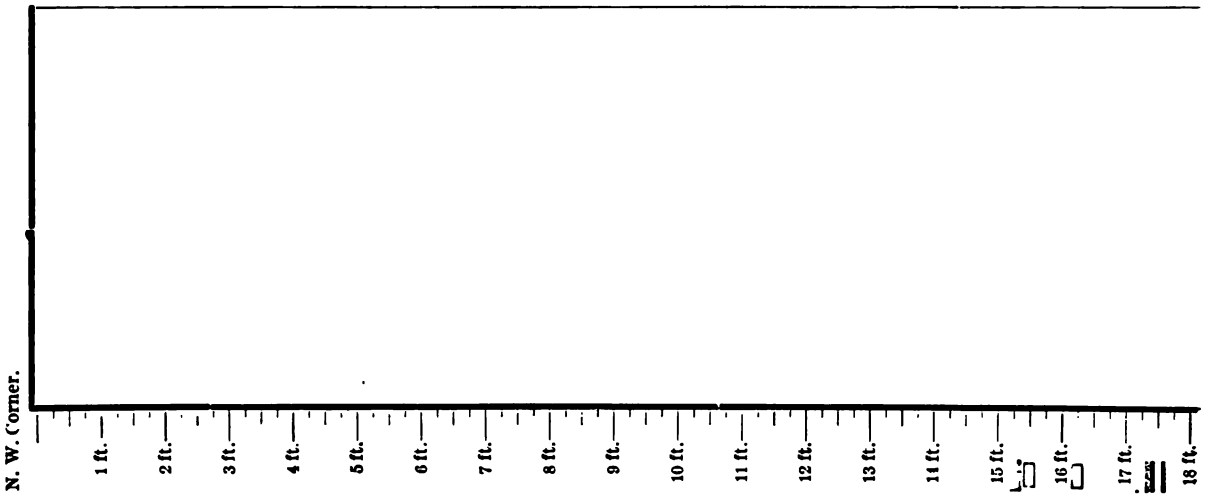
----------*heir of*----------

by----------

----------*Sexton.*

I hereby surrender to the township the unused----------*of Lot No.*---

For further record of this Lot see----



The blank represents one page of the record book as it leaves the bindery, and space for the record of one lot. The size of page being variable, to correspond with the size and shape of lots.

The first column should show the number of lot; name of person whom it is "conveyed to;" "date title was acquired;" how it was acquired, whether "by certificate from board of health," "stipulation with sexton," or otherwise, followed by signature of sexton.

After the death of the owner, the second column would show in whom the privileges become vested, and how; whether "as legatee," by "stipulation among heirs," "only heir," etc., followed by signature of sexton, cognizant of facts.

The third column shows in case an owner had used only a part of a lot, and by reason of removal, or other cause, wishes to return to the township the unused part, he could do so by filling out and signing the blank given; though, in some cases, it might be advisable to have a more formal document additional. The second blank could show where record of any surrendered part would be found. Where any certificate or deed was recorded. Where any record of action of board of health regarding lot, would be found, etc.

The scale marks the front of the diagram of a lot, the O being some uniform point on all lots. The co-ordinates of each of which if practicable, should be given. The remaining lines of lot need not be drawn to scale, but exaggerated, to give room for names. The dimensions might well be marked on them. Supposing a grave to be dug at some point on a lot designated by the owner. Measure on the ground along the front of the lot the distance from O' (in this case the N. W. corner) to the center line of the grave. At the corresponding distance on scale at front of lot, on record page right across the lot, name of person buried, age and date of burial. When a monument is erected, it can be designated by a □ at head of grave.

There is also connected with the book two indexes; the first, containing the names of lot owners, and number of their respective lots. The second (large) the names of all persons

buried, year buried, number of lot on which they are buried and remarks, thus:

YEAR BURIED.	FULL NAME.	NO. OF LOT.	REMARKS.

The column "year buried" will be found very convenient for sextons in making out returns of burials each year.

Then, if we know the name of a person previously buried, by referring to the index of burials, the number of the lot will be shown; by turning to the lot, the scale at front locates at a glance the exact position on the lot, while the plat will locate the lot.

It would be well also, to have blank record pages in the book for entering the regulations governing the yard and the amendments thereto. Also that the sexton be provided with copy of the plat.

It would be desirable to have two copies of the record books; one in the sexton's office, and one in the township clerk's office, the same to be posted once each year, to prevent loss of records by fire or other cause.

THE PRESIDENT: The gentleman has presented this grave subject very fully. The system of record is about as good as anything I have ever seen.

MR. APPLETON: It is just what is used in this city. It was an old sexton who originated it. We staked out the cemetery. He, caring for it so long, had found out just about what was wanted.

THE PRESIDENT: I should think it would be still more necessary under the system of modern cemeteries, where, as soon as possible, they level the graves down and cover them over with sod, so that the whole surface of the cemetery is a smooth surface.

MR. APPLETON: That is not done here, but it adds very much to the appearance.

REPORT OF SPECIAL COMMITTEE ON STATE BOUNDARY.

To the Michigan Engineering Society:

Your committee would respectfully report:—

This society has more than once had evidence to show conclusively that our surveyors along the southern boundary of the state have difficulty in establishing this line, or leave it unmarked. This arises from its complications as a state boundary, and also from its extinguishment. The meager field notes and poor plats, which your committee has carefully gone over, give no more certain and permanent monuments across from Lake Erie to Lake Michigan than witness trees, some being aspen, birch and maple, none better than the section lines in any part of the state.

The line adopted was run by Wm. Harris in 1817, and, along the state of Indiana, was retraced in 1827 by E. P. Kendricks. I quote from his notes to show the character of the monuments:

"October, 1827. Commenced at the southern extremity of Lake Michigan, at a corner established by Mr. Harris in June, 1817, which has its bearings as follows: An aspen 9 S, 56° W, 200 lks. and an aspen 12 S, 42° E, 184 lks. The post which was set by Mr. Harris was entirely covered by the sand. I traced his line east to his 1st and 2d mile corners and found them correct. I then traversed the margin of the lake to get 10 miles northing (here the courses and distances are inserted) which brings me 32 lks. too far north. Thence south 32 lks. on beach to commencement of the line between Indiana and Michigan. The lake coast, so far as I traversed, is a continual chain of hills formed of beautiful white sand, in most places very high, and little or no vegetation. Back of these sand hills it is generally swamp and marsh, therefore there are but few places that the lake can be approached without difficulty and no harbors or islands are to be seen. From commencement of low water mark, ran east 250 ch. to a pine 10 in. in

diameter, on top of first bank, which I marked, on north side, M. L., and on the south side I. L., from which," etc., etc.

These are specimens of the monumenting of our state boundary. No wonder, then, that citizens of one state claim to reside in the other when the tax-gatherer comes, and that criminals raise the question of jurisdiction. No wonder that highways, school districts and farm lines have become uncertain. I might also say that the Ohio boundary, although retraced by Mullett as late as 1842, is no better monumented, and that our sister state is giving the subject attention.

The Michigan legislature of 1889, by concurrent resolution No. 10:

Resolved by the Senate (the House concurring), That the secretary of the Interior be and he is hereby requested to cause a survey of the boundary line between the state of Michigan and the state of Ohio, and between the state of Michigan and the state of Indiana, to be made, and to make such arrangements for the preservation of the monuments of such survey as will secure the endurance of the same for the future.

And further resolved, That a duly certified copy of this resolution be transmitted by mail to the secretary of the interior by the governor of the state at the earliest possible moment.

Whether this urgent appeal to the secretary of the interior has caused that official to start out with his compass and Jacob's staff, your committee has not learned. It is a beginning.

In our opinion this case does not need the intervention of congress. The states interested are abundantly prepared to act; only put them into step. It does not call for fine-haired surveys on thirty-second instruments. It is a case where good, keen-eyed, level-headed engineers shall go out and take evidence of what they find and make a note of it with a proper report, and then be authorized to fix that evidence both of record and upon the ground for the many years to come.

In 1878 the state of Ohio passed an act of a similar intent.

"Be it enacted," etc., "That, as soon as practicable after the passage of this act it shall be the duty of the governor to appoint three competent persons to be commissioned to act

in conjunction with a similar commission of the state of Pennsylvania (but not otherwise) to examine as to the true location of the monuments which make the boundary line between the state of Ohio and the state of Pennsylvania, and, in connection with the said commission of the said state of Pennsylvania to replace any monuments that have been removed, or that have become displaced or dilapidated on the boundary line of said states. Said commission shall report to the governor an account of all expenditures arising under this act, together with a full report of their proceedings, accompanied by such maps and draughts as may be necessary to a clear understanding of the same, and the governor shall report the same at the first meeting of the general assembly thereafter." Severe penalties were enacted for the disturbance of the monuments set by the commission.

Then, in 1879, an act was passed to give the commissioners authority to erect these monuments. Also, in 1883, a joint resolution was adopted referring to the work done by the commission, as a resurvey and a remarking of the boundary.

"*Therefore, resolved,*" *etc.*, "That said boundary line, as marked by said commission and set forth in their report, field notes and map, is hereby accepted by the state of Ohio as the true boundary line between the state of Ohio and the state of Pennsylvania, the auditor to carefully preserve the report of the commission, field notes, maps, etc."

This brings us to the same conclusion as heretofore, namely: If this plan was good enough for Ohio and Pennsylvania, it is good enough for Michigan and the states bordering, and should be carried out as soon as may be. It is a mortifying admission that our own state land office is not furnished with better data of this boundary. A few torn plats and copies of abbreviated notes, referring to perishable witnesses, is the outfit. Your committee considers it important that this society, which is well qualified to know the facts, should ask our legislature to take immediate action on this question, and invite our sister states to co-operate with us.

Respectfully,

GEO. E. STEELE, *Chairman.*

THE PRESIDENT: What shall we do with this report?

MR. HODGMAN: I move that the report be accepted, Motion seconded and sustained. Report accepted.

MR. HODGMAN: I would further move that the committee be requested to prepare a suitable memorial to the legislature, to be presented in the name of this society, to report sometime during the meeting of the present convention. Motion supported and carried.

MR. HODGMAN: Some one of our members at a former meeting, I think it was Mr. H. C. Pearsons, at any rate, someone familiar with the work of retracing the line between Ohio and Pennsylvania made the statement that in retracing that line, the best preserved monuments they had were wooden stakes. The stakes outlasted the stone monuments that had been built with great care.

The following memorial was prepared by the committee and approved by the society:

MEMORIAL.

To the Honorable, the Legislature of the State of Michigan:

Your petitioners are members of the Michigan Engineering Society and would respectfully represent:

That, we have, through a committee appointed two years ago, made investigations as to the condition of the *State boundary* between the states of Michigan and Ohio, and the states of Michigan and Indiana, a report of which committee is subjoined.

In view of the importance of the subject, in the settlement of the various questions constantly arising, and of the proper perpetuation of these boundary lines, we would ask that immediate attention be given to the subject by the enactment of a bill, by which the Governor will be authorized to appoint a commission of three members, to co-operate with a similar commission from each of the states interested. First, to

report on the exact condition of said lines; and second, to properly perpetuate them.

E. W. Muenscher,	John J. Granville,
D. Skeels,	Geo. W. Doane,
Wm. Appleton,	O. C. Goodale,
Wm. B. Sears,	M. H. Bailey, Eaton Co.
H. F. Bean,	Sam'l E. Jones,
F. H. Williams,	H. L. Thayer,
A. L. Marhoff,	H. E. Riggs,
E. W. Redman,	A. J. Teed,
F. F. Rogers,	E. O. Sellers,
Wm. G. Fargo,	F. Hodgman,
Dan. J. Albertson,	Geo. E. Steele,

Frederic L. Church.

ADDRESS OF MAYOR BEMENT.

Mr. President, and Civil Engineers of Michigan:

One of the pleasing and innocent occupations of the Mayor of this city is to welcome to its borders various bodies of men who come here to hold their annual meetings, and I assure you it is a great pleasure to welcome you here to-day.

Now it is customary on an occasion of this kind to remark, and I will say that I have made this same remark a number of times, that you are certainly a fine looking body of men. It is not necessary for me to say that I am highly pleased with your appearance.

I think perhaps that I may have a slight conception of what is expected to-day of a Civil Engineer in Michigan. I only have a slight conception, but I have wished a good many times, since occupying my present position, that the Civil Engineers of Michigan, and particularly those of Lansing, might have had at least one hundred years experience. The building of a city I do not know very much about, but I do know that beginnings and small things oftentimes do grow into large things, and the desirability that somebody should know at

the beginning what they are going to grow into. If that were possible, I know that we should have saved a great many mistakes, and a great deal of useless expenditure of money. I have sometimes thought that even in the smallest villages if they should employ a competent civil engineer, when it was simply a village, and should pay that man a good salary, that the amount he might be able to save to that village corporation would more than compensate for the salary.

How much more is this true of our larger cities. How much more it is true that a man who is taking charge of the work of building a city, should be thoroughly equipped for his work. Most people have to be trained to their occupations, and I can readily see what a task you all have before you in equipping yourselves for the work which you are expected to do.

Therefore gentlemen, I take especial pleasure to-day, in welcoming you to Lansing, and saying to you that I believe that not only our city government, but that our citizens generally appreciate the position you occupy in the industrial progress of the country in laying out our cities, in making them beautiful, in furnishing them with good sewerage and good streets, and all those things which go to make up a fine city, of which I think no state has more, than our beloved Michigan, and I have no doubt that it is very much owing to your efforts that such is the case to-day.

I therefore say to you, gentlemen, you are welcome to Lansing, and I take pleasure in handing you the keys of the city and saying "come in and take possession of it."

THE PRESIDENT: In behalf of the society, I beg to return our thanks for your cordial greeting. I am only sorry that the engineers are never speakers. But perhaps the best reply I can make to your welcome is to assure you that it will not be necessary to increase your police force on our account, while we are present with you.

GOOD ROADS.

BY E. W. MUENSCHER.

[Chief Engineer M. & G. R. Railroad.]

In opening the discussion of the subject of "good roads," I think I can truthfully say that there has never been a time in the history of this country when there was so general and deep an interest in this subject as there is to-day. Much of this interest is due to the efforts of the League of American Wheelmen, whose publications have been widely circulated, and have been instrumental in diffusing much information among the masses of the people. They have also been the means of awakening the interest of the press of the country, and we engineers and surveyors are now receiving a large amount of gratuitous instruction in the art of road building from the omniscient editor. It is presumably intended for others less fortunate than ourselves, but there is no law which forbids us too from drinking at this perennial fountain of wisdom, and often perhaps with profit.

But the American people are apt to run to extremes, and while there is much that is being written and said that is wise and just and timely, there is also much that is unreasonable in the complaints and criticisms which we sometimes hear from the more zealous advocates of road improvement. While we are free to admit that the roads of the state of Michigan are far from being what they ought to be for the best interest of the state, and that it would be difficult to exaggerate the wretchedness of their condition at some seasons of the year, we should not forget that the state is not yet 55 years of age, and that over a large part of her territory still waves the primitive forest. Her first settlers were poor men who came with but little capital beyond their stout hearts and willing hands, to subdue an unbroken wilderness. Their lives were spent in the hard toil of clearing off the timber, pulling out the stumps and breaking up the virgin soil. They had no time, nor means to devote to road-making, beyond the simple wagon track over

which they hauled their scanty crops to the nearest market. The accumulated fruits of their toil, and that of their children, have been absorbed in the construction of homes and out-buildings and fences, and churches and school-houses. These were the prime necessities of a civilized and christian people, and until they were provided other things which seemed to be less essential were obliged to wait their turn.

It has been a work of years, and while it was going on but little could be done in the way of road construction beyond what absolute necessity required. Over the greater part of the state this work is still going on, or is not yet begun, and yet we are reproached because our roads, built as they have been solely by voluntary contributions from the hard earned savings of a free people, do not always compare favorably with those of Europe, which have been the gradual growth of centuries of civilization, and too often the product of enforced or enslaved labor.

Twenty-two hundred years ago the Romans were building roads almost as solid and enduring as the eternal hills from which the rock was taken to pave them. Eighteen centuries ago Pliny was writing specifications for road construction, which would not be bad at the present day, and which read marvellously like the strictly original productions of some of our modern engineers. Nine centuries ago the wandering follower of the Prophet could travel ten miles in a straight line along the paved streets of the Moorish city of Cordova by the light of street lamps. The paving of the streets of Paris was commenced 700 years ago, and of London but little later. The most ancient of these works survived for use and example and instruction, even through the ages of darkness and ignorance, and superstition, mud and filth that spread like a pall over Europe, and since the invention of printing, and the dawning light of religious freedom began to lift the cloud, more than 350 years have elapsed, (seven times the life-time of the state of Michigan,) through which inch by inch could be added to the relics of long past industry and wisdom. Give Michigan three centuries more of life, and she will show you roads all over her vast territory, over which even a Roman Censor or a Saracen Caliph need not scorn to ride.

But, however reasonable this excuse may be for past deficiencies, and however justly it may still be urged for a large portion of our state, there are many other portions to which it will no longer apply. There are whole counties in the southern part of the state, and many townships and neighborhoods elsewhere, in which the laborious pioneer work of clearing off the forests is largely completed, churches and school houses are provided, surplus capital is beginning to accumulate, and the time has come when it is possible, in these sections at least, to begin the work of building good roads.

What, then, is required to start the good work? The reply is: 1st, Education; 2d, Legislation; 3d, Action. Many of us perhaps would like to skip over the first two stages and begin with the third. In a despotism this would be possible, but under a popular government like ours, never.

Roads cannot be built without money; money cannot be raised without taxation; taxation cannot be levied without legislation; and no legislation could be of any permanent avail unless demanded and sustained by public sentiment. To create this sentiment is the first necessity of the hour. The people of the state must be convinced, 1st, that improved roads are good things and, 2d, that they can afford to put their hands in their pockets to pay for them. So far as the first of these two points is concerned, but little remains to be done. There is not one man in ten in the state of Michigan who does not know that good roads would be a blessing to himself and the whole community. We read a great deal just now about the necessity of educating the farmer, but, as I believe, without good reason. The farmers of Michigan are, as a general thing, an intelligent and wide-awake set of men. Though, as a class, they may not be able to figure out, in dollars and cents, the precise annual loss which they sustain by reason of bad roads, or to apply the most efficient remedy, they are generally very thoroughly convinced that good ones would be a great boon to them. Indeed, I am inclined to think that no class of men is more fully aroused to the necessity of road improvement than the farmers. They know that first-class roads mean to them the ability to go to market at

any time in the year; to take advantage of the best prices and the best markets, and to put the difference in their pockets; to haul double the load in half the time, and thus save a large amount of labor and time, to be applied, with profit, to their farms; to get along with fewer horses and save in purchase price and cost of keeping; to introduce a more varied and profitable husbandry by cultivating garden truck and other perishable produce instead of the low-priced grains to which they are now confined. They know, too, what is of even greater consequence than mere pecuniary profit,—that good solid roads mean the breaking of the blockade of mud which now shuts them and their families up in their houses during much of the year. They mean the ability to attend their churches and farmers' clubs and social gatherings, or to visit a neighbor, or to go to town to a concert or lecture whenever they feel like it. They mean daily mails and free delivery, and larger school districts, and better teachers, and better graded schools, from which their children will not be kept away one-fourth of the time by the depth of the mud. They mean all those intellectual and social enjoyments, the absence of which is the crowning evil of rural life, and, more than anything else, is driving so many of the farmer's sons and daughters to the cities, and so many of their wives to the asylum or the grave.

Why, then, do we not have good roads? Mainly because the farmers know that, under our present road system, the entire cost of these roads would fall upon them, and it is a burden which they are neither able nor willing to bear. The wheelmen, the merchants, the residents of cities, the railroad companies, would all share largely in the benefits of good roads, but would contribute nothing toward paying for them. Until this obstacle is removed we need not look for improved roads, and all our arguments and demonstrations will be in vain. This can only be done by legislation, and it is to our own state legislature that we in Michigan must look for relief.

It is true that some are advocating the adoption of a general system of road improvement by the general government, and it has even been proposed to create a new department with a cabinet minister and a few score of clerks to tell

us how to build a road, but it is not at all likely that any such project will succeed. The general government is likely to have its hands full for years to come in discharging its own legitimate functions without assuming those of the states, and if it will only keep our rivers and harbors in shape to accommodate our commerce, we ought to be content.

The commissioners appointed by Gov. Winans to investigate this subject have reported that, under the provisions of our state constitution, the necessary legislation cannot be obtained, but this need not discourage us from considering what this legislation ought to be, for there should be no doubt that, in the present condition of public opinion, our legislature will promptly submit, and the people as promptly ratify, any necessary amendment.

As to the details of the required legislation, there will be much difference of opinion and much need of wise counsels. Especially will it be necessary to avoid running into extremes, either as to the amount of work to be done or the material to be employed. Great as is the evil of bad roads, that of excessive taxation or of crushing debt might be still greater. Whatever is done must be limited by the ability of the people of the state to pay for it without distress. Upon one point there will doubtless be a very general agreement, and that is that the present system, both of raising and expending the road funds of the state, should be abandoned. One of our most intelligent farmers, in an article in the *Grange Visitor*, of December 1, 1892, which is well worth reading, estimates the the total amount raised annually in the state for road purposes at a little more than $2,000,000 in money or its equivalent, and that not less than half of this sum is wasted on the wages of useless officials and on inefficient, misapplied and misdirected labor. All of us who have ever seen the average highway commissioner and his neighbors working out their road tax by scraping the sods and silt from the sides of the road into the center, or have ever had occasion to examine the average highway bridge, will readily agree that this estimate is not far out of the way. But, even if the entire amount were wisely expended, it would be far below what is necessary. Accord-

ing to the 11th census the land area of the state of Michigan is 57,430 square miles, or about 1,600 ordinary townships six miles square. This would give each township, on an average, $1,250 a year. Deducting the necessary cost of repairs, superintendence and administration, there would not be enough left to build half a mile of reasonably good road. The first mile built would be worn out long before the last one was begun. We must certainly have more money, but how to raise it without imposing too heavy a burden upon the people will be the most difficult question for the legislature to answer. It concerns us rather as citizens and taxpayers than as engineers, but it must be answered satisfactorily before the engineering question can come up at all.

It will not be far out of the way to assume that in each ordinary township there is now, or will be eventually, about seventy-five miles of highway. Estimating the average cost of a good gravel or other improved road at $2,000 per mile, the entire cost to the township would be $150,000, or about $6.50 for each acre of land in the township, and $520 for each 80-acre farm. It is safe to say that there is not a township in the state that either would or could attempt to raise this amount in a single year, or even a short term of years. It would be equally unwise for any township to load itself with such a burden of debt for the purpose of completing the work at once. It is plain that the work of construction should be spread over a series of years, and the work of payment over a still longer period. All the benefits of good roads will descend to our posterity, and there would be no injustice in asking them to pay part of the cost. Suppose each well-settled township should undertake to build its system of roads in, say, ten years, beginning with those running each way from its railroad station or principal market town, and pay for the same partly by an annual road tax, somewhat larger than the present one, and all paid in cash, and partly by bonds running from ten to thirty years, so divided that the payments each year should be approximately equal. The burden would thus be distributed over forty years, and would not be severely felt, while the benefits would be realized within a very reasonable time.

It might be advisable to assess part of the cost of each road upon the district immediately benefited, as is now done in some states, and is very common in our Michigan cities in the case of street improvements. But, even if this policy should be adopted, a part of the amount should be raised by general tax upon all the property of the township or county, so that all who are to enjoy the benefits may help to bear the burden. How far the state at large may share in this work, beyond providing the necessary legislation is a disputed and delicate question. My own judgment is, that in view of the unsavory odor of fraud and favoritism and extravagance, which has attached to most of the past efforts of the state to carry on internal improvements, it would be the wisest policy for her to keep her hands off entirely. She should, however, guard against unwise parsimony on the part of local authorities by prescribing standards of construction, to which all improved roads must conform, just as she now does in the case of toll-roads. She might also very properly aid the work by the carefully guarded loan of her credit. Our state is practically out of debt, her credit is very high, and her indorsement upon county or township bonds issued in judicious amounts for road construction would enable them to be sold readily at par, at low rates of interest. The burden upon the people would thus be largely diminished, while the state, being only an indorser and having the supreme power of taxation for the security, would be perfectly safe.

She could also aid indirectly by legislation, encouraging the use of wagon tires wide enough to pack down an improved road after it is built, instead of cutting it into ruts, as is now common.

But whatever means may be employed for raising money for the construction of a system of improved roads, success cannot be expected, unless the work is done under the supervision of competent men. And here there will be need of much caution. The fact that a man has received a majority of the votes in a county for the office of county surveyor, in a heated political contest, in which all personal qualities are often lost sight of in the struggle of two great parties for

supremacy, is no criterion at all of his fitness for this duty. Under our present laws, there is nothing to prevent a man from being so elected, who does not know the difference between the jacob-staff and the needle of his compass, and even if he were most thoroughly qualified for the ordinary duties of a county surveyor, it does not at all follow that he would be a competent road builder. A man may be an excellent land surveyor and yet know little or nothing of road making, or any other branch of engineering construction. For this reason it would be very unwise for the legislature to attach the duties of a road superintendent to the office of county surveyor by force of law. At the same time his public and official position, his presumed knowledge of the use of instruments, and his affiliation with the political party in control in his county, would naturally commend him for appointment to the charge of the road work of the county if he possessed the other necessary qualifications, and this fact should be an inducement to those who now fill that office to acquire those qualifications, and might possibly lead in the future to bringing a higher order of talent and acquirements into an office which now has but few attractions, and very generally goes begging. What these qualifications should be, and how they should be tested, it must be the duty of the legislature to prescribe, and the best interests of the people of the state require that the duty should be carefully performed. If no test at all should be required, the probabilities are, that in very many localities, motives of economy or of personal or political favor would lead to the appointment of men poorly if at all qualified for the work. Some test should be essential, and I know of none better than the certificate of a competent and honest Board of Examiners, and that board might well be composed ex-officio of the professors of engineering and surveying in our State University and Agricultural College. They are men who have been appointed to their positions by reason of their high attainments in the branches of knowledge with which a superintendent of roads should be familiar; they are specially qualified by their long experience as teachers for finding out just what *a man* really knows; they are happily free from the restraints

and prejudices and temptations which might affect the action of a local or political board, and their being already in the employ of the state would considerably diminish the cost of their work.

In many of our counties there would be no difficulty in finding more than one man who either is already qualified or could easily make himself so by the study of the many excellent treatises on road making which are now in the market, but in others, it might be more difficult to find material, and for their benefit it would be policy for the state to provide a special course of instruction in road location and construction in the University or Agricultural College, or both, during the winter months when those for whose benefit it is intended could most readily attend. The only expense would be for the necessary additional instructors.

If in addition to this provision the state would publish in cheap form, and distribute to all the supervisors and county officials of the state a compact treatise on the construction, improvement, care and repair of common roads, including those of gravel and broken stone, together with approved general specifications, it would be of really more interest and value to the people of the state than a majority of the reports which it now issues.

It is not my intention on this occasion to say anything on the engineering features of this subject. I hope to hear this better done by others. I will venture, however, to touch briefly on one other point in which many members of this society may well take an interest. No interest in the state of Michigan would be more benefited by good roads than the railroads. During a large part of the year much of their rolling stock is lying idle because farmers cannot bring their produce to the station. At other times they cannot get cars enough to haul away this produce, and sidings and elevators and warehouses are gorged to overflowing; extra train forces must be employed; men in other lines of traffic who need cars are denied, and general disturbance of business, delay and loss follow. Good roads would distribute this business more uniformly over the year, to the mutual advantage of the com-

panies and their patrons, to say nothing of the increase of population and production and prosperity which would follow. These railroad companies are usually very earnest advocates of good roads, but, under the laws of this state, they do not contribute one dollar toward their construction. This is an injustice which ought to be remedied if possible, but, whether it ever is or not, there is one way in which the railroads might greatly help on and hasten the good work without cost to themselves. If we are ever to have anything better than dirt roads in Michigan, we have got to depend almost entirely upon gravel. This material is found in vast quantities in the drift which covers the entire lower peninsula, but the deposits are local, and there are large sections in which a stone as large as a hazel-nut would be a curiosity. The cost of hauling gravel to such localities is so great as to forbid its use. It is here that the railroads could do a good work. Most of them pass through or near large gravel beds. If, at times, when many of their flat cars are lying idle, they would load them with gravel and deliver it at each station along their lines at bare cost, to be used in building gravel roads each way from those stations, they would greatly diminish this most serious obstacle. Some of them also own steam excavators, which, at times, could be used in loading the cars, with a further saving in cost; and other roads might well afford to purchase these excavators for this purpose. It might even be policy for each road to keep on hand a few miles of light rails and ties to be laid down temporarily along these highways, over which the gravel cars could be hauled, and unloaded by machinery, with another considerable saving. This idea is not a new one, for it has been put into practice, to some extent, by some of the roads in Indiana and Illinois, with good results to themselves and the country through which they run. The roads of Michigan might well follow the example, and if the members of this society who are connected with them would use their influence with their superior officers, to induce them to try the experiment, they might accomplish much toward hastening the day to which we all hopefully look forward.

EAST PARIS, January 17, 1893.

E. W. Muenscher, President Michigan Engineering Society:

DEAR SIR: I regret that I have been unable to prepare a paper on the subject of roads, as requested, for your meeting. What the farmer wants now is laws that will compel all property and all people to pay its and their full share of the expense in making good roads, and a knowledge of the probable cost of such roads. The farmers have given all the land for the public roads, and, since the settlement of the country, have paid all the taxes for road improvement. The public have had the use of the roads, and only part of the public—the farmers—have borne any of the burden of making them. There has been no law by which they could avail themselves of the skill of the engineer or surveyor, consequently all roads have been made by guess. One-half the labor and money expended for the last fifty years, had it been expended under the direction of competent engineers, would have given us infinitely better roads than we have to-day, and the foundation would have been laid for much better roads than we can now make, unless at greater expense than if we had started right. Without the aid of the engineer we never need look for good roads. Men do not build houses or public buildings without first consulting the carpenter or architect, nor do they engage in an important lawsuit without consulting a competent lawyer. I would suggest that your meeting give to the public an estimate of the probable cost of good roads, to be built by contract, under the superintendence of proper commissioners and engineers. A first-class road is better than our present "toll road." It is not expected that we will at once enter upon a system of road improvement and make finished roads equal to those in the "Old Country," but we can make a good beginning, and, in time, make complete finish. Your members, coming from all parts of the state, will have some knowledge of the available material for making the roads. Give an estimate of the cost of preparing stone by machinery, for *stone* roads; the amount required for the

ordinary travelled roads; the cost of a stone road as compared with gravel roads, where the material of the one is as accessible as the other; the cost per cubic yard of crushing the stone found commonly on the farms of the state; the thickness of stone required for a stone road, and the thickness of gravel for a gravel road. The farmer wants good roads and must have them before he can enjoy rural life as he should. When we get good roads we shall get free delivery of our mails. Good roads and the free delivery of our mails will both come at the same time. When we get both, farm property will have greater value, and rural life will be more attractive and enjoyable. I think the more intelligent public, if not all the people, will give thanks for whatever information and advice your intelligent body of engineers may see fit to give. Prejudice will exist for a time, but will soon give way under the second sober thought of the people. I shall look for good results from your meeting. Truly yours,

S. S. BAILEY.

IMPROVEMENT OF COMMON HIGHWAYS.

BY R. C. CARPENTER, ITHACA, N. Y.

As many members of the society no doubt remember, the writer has discussed the question of Road Improvement, by lectures, and by articles which have been published in the Reports of the state Board of Agriculture. The effect produced by these articles have seemed quite insignificant, and a more extended experience has led me to believe that the question of road improvement is to be first discussed as a social and political question, rather than as an engineering one. There is little use in giving information regarding the construction of roads, unless a desire can first be kindled for better roads. The people should be taught that better roads will pay, that it is poor economy to waste time and animal power in dragging light loads over muddy roads. If they can see that good roads pay, then they may be induced to build *good* roads. The present movement is the first that has been

started that has had any chance of success, and this is due to the fact that the movement has been conducted in a manner to appeal to the pride and interests of the people. It is the duty of every engineer to press onward with enthusiam and urge in every possible manner the success of the movement. This should be done from the standpoint of the citizen, and not from that of the man who sees in the success of the proposed movement, a job in the distant horizon. Indeed, such advocacy will imperil the success.

When the people have been led to the idea of road improvement, then will they listen to technical methods and plans of securing such improvement. To-day the question is more of a political one, and the attention should be given principally to the ways and means of securing public interest and public attention.

While it is certain that there is no public investment that will return so much to the rural population as that put into road investment, still the fact must be faced, "that good roads will cost money," and the people are not accustomed to put good money on the roads.

You will find also that in your state the wheels of progress are blocked to a great extent by your existing road laws.

I do not refer here to the system of paying the road tax in labor, which has so long prevailed in nearly every portion of the country, but I do refer to the senseless method of dividing up townships into districts for road improvement. The payment of the road tax in labor, is in my opinion, not the bar to improvement that so many have claimed, and considering the small amount annually expended, I believe as much has been accomplished as could have been done with cash. It is true that the labor has often been badly directed, and the improvement which resulted of a negative character, but I think no one believes that the same talent that so lavishly wasted and misdirected labor would have done any better with money. The remedy is not to be sought primarily in a money tax; no tax can be used to benefit the highways, until the law permits a combination, of all the parties interested in road improvement of a partial highway. The present system divides the country in sections of small extent, with some main road, and

a great deal of back road. It often happens that the men who work the road and pay for the improvements, rarely travel over it, and have no personal interest in the road at all. Again the system does not admit of different trial improvements, each land owner secures about the same expenditure to the road adjoining his premises, whether the road is of importance or not. The expenditure of the labor or money with such a system is attended with diffculties which will surely defeat the object sought.

A township district, since it is larger, might in some respects, be an improvement, but even here we should find a want of interest, or perhaps a clashing of interests that would defeat the best laid plans. The true road district is one formed on natural laws, and by a community of interest of those who use a given highway, and is made regardless of township or even county lines.

It is no doubt practicable to provide that a certain district interested in the improvement of a given highway can combine, and organize to improve that highway by taxation of all the property benefited. Such a law would result in the construction of trunk line roads leading in various ways from the principal market towns, which would in this way afford with moderate cost, the benefit sought in the proposed improvement.

It would also result in the construction of cross roads or by-roads, branching at intervals, as the people require, from the more substantial and better built main roads. The latter system could be organized as independent of the present system, and a money tax could be raised for the principal highway, which in such a case should be released from the supervision of the present authorties.

The above system is urged because the writer believes, first, that it is practicable; secondly, that it will impose less hardship upon those who are interested; thirdly, that it will result in producing the desired improvement with less cost than any other plan of organization. It will be less costly, for the reason that the district improvement is on a sufficient scale to provide good engineering talent, and good supervision; fourthly, it will meet with less opposition since it permits the

organization of people with a common interest, and provides for the distribution of the cost among all those benefited.

What may seem as a model of the method proposed has already been tried with success as applied to public drainage, and this has resulted in much good, and serves to indicate that such a scheme is feasable and will be successful.

THE NEW ROAD LAW.

BY SETH DEAN, GLENWOOD, IOWA.

What shall the new road law be? This is the question that both engineers and taxpayers are asking at this time in a great many of the states of the union; and, truly, it is a much easier question to ask than to answer, for past experience warns us that, unless we can provide a better law in all respects than the one we have, the public will be the loser by the change. The first consideration of law-makers should be to so frame the law that the greatest benefit may be realized by the public for the least expenditure of money, not only in the first cost of the work, but in the annual cost of maintenance after the work has been constructed, as well. With this view the writer offers the following plan as his idea of the proper solution of the problem:

For the convenience of officers who have charge of the construction and repair of roads under the plan presented, they should be divided into four classes, as follows:

Class No. 1 should include all roads which now are, or are destined in the near future to be, main thoroughfares of travel. These are usually the direct routes between cities or business centers of the country. These roads, if not already established on the most economical route, all things considered, should be revised and, after a thorough examination of the country, be placed on the best ground, and then be made of proper width and grade to accommodate the travel, and the surface paved with brick or covered with some other material suited to the climate and conditions of travel.

Class No. 2 should include the principal routes of travel between the smaller cities or the principal towns. The

location of these roads should be made with the same care that those of the first class are, with respect to alignment and grade, and should be covered with some suitable material, not necessarily as heavy or expensive as that on No. 1, but suited to the conditions of the case.

Class No. 3 should include the principal country roads, usually those leading into the market towns or cities from the country. These roads should be located as much with reference to the accommodation of numbers of the people who will use them, as to the sole matter of grade, but they ought not to be diverted from their general direction to accommodate one or two parties. This class of roads, too, should be well drained, and, if circumstances will permit, may be covered with gravel or some other suitable material.

Class No. 4 may include all the so-called neighborhood roads, or those which, from their location, can at most be used only as a means of communication between small sections of territory, and for school purposes, but which the public has a vested right in, and is bound to keep in repair. This class of roads should be located, as much as possible, to accommodate the inhabitants of the section of territory through which they pass, and, if necessary, they may be located on almost any line or grade, so long as the location is one that does not endanger the lives of persons or animals that are compelled to make use of them; but, of course, a judicious use of practical common sense in their location will save the taxpayers money in the way of maintenance, and the public much vexation in their use. Next, all highway taxes should be collected in money by the county treasurer, and paid over by him on warrants issued by the proper authority. All work of construction or repair of roads should be done under some form of the contract system, the contractor furnishing a guaranty in the form of an approved bond, or to receive no pay until the completion of the work to the satisfaction of the proper officers.

HOW CAN THIS RESULT BE SECURED?

There should be appointed and duly commissioned, by the governor of the state, five persons, who shall constitute an executive board of highways, two members of which should be civil engineers and one a lawyer. The remaining members

may be men of business ability. The duties of this board should be to divide the state into suitable highway districts, consisting of, say one county, more or less, according to the circumstances of the case, having more regard to the density of population and the topography of the country than to the present political divisions, the design being to, as nearly as possible, adjust the total mileage of roads so that the cost of maintenance shall require as light a tax as possible on the people. They should determine all question of dispute in regard to the proper classification of roads made by the district boards, hereafter described, when appealed to them. They should examine and approve all plans for bridges on roads of the first class and the plans for all bridges of two hundred or more feet span on other roads. They should keep complete plats and records of the notes of location and profiles of grades, together with copies of the plans and strain-sheets of all bridges on roads of the first class; and in cases where roads of the first or second class run through two or more districts, they should have the power to call special elections to vote on the question of the issue of bonds for the grading and paving of such roads through the several districts, and a majority vote of the people of the several districts as a whole should decide the question (provided, however, that individual districts may, by vote, issue bonds for the purpose of paving or grading that portion of the said road that runs through their territory, independent of other districts, at any time they desire to do so).

They should have power to examine all applicants for the position of district engineer, and to grant certificates to all who can pass the required examination.

They should annually make a full and complete report of their work to the governor, together with such recommendations as they may think proper.

There should be created two offices—a superintendent of highways and a district engineer. These officers should be elected by the voters of the district, and they should each hold their office for a term of two years, and should give good and sufficient bonds for their official acts. Each should be permitted to name his own deputies, if any were required. And

before a person could be eligible for the office of district engineer, he should be required to pass an examination and secure a certificate from the executive board. The duties of these officers should be as follows: The two together to constitute a local board, who shall have a general supervision of all highways in their district, and make a classification of the same. They should divide the district into such number of precincts as may be most convenient for the purpose of contracting the work of maintenance or repair of roads and bridges to advantage. They should open all bids and award all contracts for grading or repairs on roads, and for the construction of bridges.

They should have the power to establish, alter or vacate highways when petitioned for by the citizens of the district; and, in cases of relocation of highways of the first or second class, they should have the power to condemn land for road purposes, or for the purpose of constructing proper outlets for drains through adjoining lands; but before commencing condemnation proceedings, such plans of drainage, or of changes in existing highways should be approved by the executive board.

They should annually file with the board of county commissioners, or other proper authority, a sworn statement of the amount of work done during the year on the roads in each of the different classes, and of materials or supplies purchased, and of the amount of funds on hand, and also with an estimate of the amount of funds that will be required for the maintenance of the roads and bridges in the several precincts for the following year, and also an estimate of the amount of money which can properly be expended in grading and paving or macadamizing of roads in the several classes, from which estimates the commissioners should make the proper tax levies.

They should annually report to the executive board the number of miles of roads of each class in the district; the amount of grading and paving or macadamizing done; the cost of the same; the character, amount and cost of bridges erected, and of repairs to existing bridges, together with an estimate of

the amount of funds required for the several purposes for the following year.

Besides his duties as a member of the district board, the superintendent of highways should have the general supervision of all highways in his district when the district board is not in session. He should receive all petitions for new roads, or changes in existing ones that may be filed with him by citizens of the district. He should examine all routes petitioned for, and, if satisfied that the new road, or the change of the old one, is desirable, should notify the district engineer to make a survey of the same. He should advertise for bids for the general repair or the construction of the roads and bridges in his district, and, after the work is awarded by the district board, should sign all contracts. He should purchase all supplies necessary for the use of the district in the care of the roads. He should issue all warrants on the road fund on the treasurer's fund of the county where the work was done, based on the monthly estimate of work done by the contractors filed with him by the district engineer. He should keep a full and complete record of all his acts, and a register, by numbers and amount, of all warrants issued by him, which books and records should be open to examination by the county commissioners or the executive board at all times, and should have his office at the county seat, or in the city or town most convenient of access to the citizens of his district.

In addition to his duties as a member of the district board, the district engineer should make all surveys of highways in his district, and properly mark out on the ground all construction work for the contractor, and keep complete records of the location and field notes of surveys of highways, together with plats and profiles of all grades established, and copies of the plans, strain sheets and bills of material of all bridges built, and copies of the final estimate or measurement of all grading, paving or macadamizing done. He should furnish the superintendent of highways with plans and, if necessary, strain sheets for all bridges, and for bridges on roads of the first class, and for all spans of two hundred or more feet in length on other roads; he should first submit his plans and strain sheets to the executive board for approval before finally

giving them to the superintendent for the use of builders. He, too, should have an office at the county seat or most accessible point for the citizens of the district, and his records, books, etc., should be open for examination by the proper county officers or the executive board at all times.

Such, in short, is the plan the writer would propose as a remedy for the present expensive system, in use in most states, of working the roads. That it may have weak points, he does not doubt, but he also believes that it possesses some merit. It is quite probable that some states have laws at the present time wholly or in part similar to the plan outlined here; if such is the case, the success or failure of the plan, where it has been put in practice, can be easily learned from those who have tried it, and who can readily point out its defects, for no amount of theory is equal in value to an experiment, in the matter of either making laws or putting them into practice. He is convinced, however, that the plan he has outlined will be productive of better roads and a material saving of money to the taxpayers in states that can be induced to try it.

WAGON ROADS.

J. H. FORSTER.

Admitting that good wagon roads are of great advantage to a country, and that our roads in general are not what they should be, not what they might have been, if the labor and work expended had been judiciously applied; we are of the opinion that better methods of improvement are in order.

We hope that some wise plans may be adopted from the general discussion of the state of our highways now going on, and that practical methods may be reached.

But in many newspaper articles on country roads, I think our country is treated unfairly. It is not fair to compare our country roads with those of Europe. Michigan for example is a new state. In Ingham county where I reside, the oldest settlers boast that it is 35 or 40 years since they built their first *log* cabin in the wilderness, reaching their destination by

Indian trails. Thirty-five, forty, even fifty years--what an age! Compare it with some older civilization which we call modern. The English, French and German people with whom we are unfairly compared in the matter of roads, have been building for a thousand years. Their primary teachers were the Romans. Good military roads were as necessary to those invincible historic conquerors as are railroads in modern times. They used their power and compelled the conquered people and innumerable slaves to work upon their marvellous thoroughfares. But as I understand it, their system of roads was limited, not general. They built only a few great thoroughfares connecting important parts of the conquered country. It was so on the continent.

But in Michigan no despotic power has hauled us out to work on the roads. On the contrary, we have lived under the mildest of regimens. Our Centurian has been the popular *path master* (not road master!) carelessly elected by a *viva voce* vote of men and boys, with no special qualification, no ambition other than to get through with the job of making bad roads worse as cheaply as possible. This statement is made in general terms; there are praiseworthy exceptions. Better, more carefully made roads are becoming more common. Many farmers are fully aware of the importance of good roads.

Many enthusiastic advocates of good roads will have nothing but stone, or McAdam throughfare. At this time the proposal is absurd. I have to work 1½ miles of road on my farm. A first-class stone road would cost say, $5,000 per mile. My farm would be taxed $7,500. It is assessed at $15,000, therefore it would take one half of the farm to build the road. But from whence is the money to come? By mortgage? The state would better confiscate the farm at once and set me at work breaking stone for a living. In no possible way could the McAdam ever reimburse me for the tax, even if I could pay it.

Therefore, so far as we farmers are concerned, I would say, "go slow."

Farmers use only certain local roads. In our section, owing to the nature of the soil as much as anything perhaps,

we have pretty good roads. By good drainage, turnpiking, putting gravel and sand on a clay road-bed and clay on a sand road-bed, good results follow. Our roads, even under a lax system are slowly improving.

The general public use all the roads in a county, and many who travel, pay little, if any road tax anywhere. So it seems to me if the present system of road building is to be improved or changed, the work should be placed in the hands of the state, and all villages and cities as well as townships and counties, all railroads and ship lines should be taxed to build county or state roads.

It would be unjust, unfair and ruinous to throw the burden of costly road building upon the township. You would kill the goose that lays the golden egg.

Unfair as it might seem at the first glance, to tax steamers and railways for land roads, I think upon examination the tax will not appear unjust.

In the first place, millions upon millions of the people's money are expended in the construction of harbors, light houses, locks, dredging, etc. The common roads of the country lie behind all these.

In the second place, good country roads are a very important factor in railroad traffic. What is the condition of things to-day, especially in the western states? Railroads may be viewed as the main streams of inland traffic. The common roads as innumerable feeders. It is of the utmost importance in railroad traffic that the flow of passengers and freight be strong and constant all the year round. But the choking up of the common road feeders by mud, is a great draw-back. When the roads are good after harvest, all of the railroad stations are filled to repletion. The farmer hurries in his produce irrespective of the condition of the markets, while the railroads are unable to remove the crop fast enough. All are working under undue pressure and at a loss on one side, at least the farmers.

During the muddy term, the railroads receive a minimum of freight and run empty cars into half stranded cities.

Good roads, all the year round would even up things and conduce to general prosperity.

In a new country like ours, under so many varying conditions, the permanent improvement of country roads must be a work of time– much time. It will not do to force matters. The best engineering talent (such as we have here!) must be employed in planning and executing, supplemented by wise and honest legislation and *administration*.

HIGHWAY LAWS OF NEW YORK.

BY O. C. GILLETTE.

At the request of our secretary, I have made the following digest of the highway laws of the state of New York.

There has grown up in this state in process of time, a vast body of fragmentary and disjointed legislation, and it requires more skill than I possess to tell in all cases what is law and what is not. For instance: I read through two or three pages of an enactment in reference to highways lying in two or more towns of a county, only to be told in the last clause that this act applies solely to counties lying contiguous to cities having a million or more of inhabitants.

In each town in the state outside of cities and incorporated villages, there are annually elected one or more commisioners of highways. They have supervision of the roads and bridges of the town. They are to divide the town into road districts and to appoint officers called Path Masters, who see that the highway tax is properly worked out on the roads. The highway commissioners may expend not to exceed $250.00 on the roads and bridges of a town. If they require more than this, they must give due notice previous to the annual town meeting, stating the objects and the particular amount required for each.

They may cause a survey of roads which are not well described, or which, though not regularly laid out, have been in public use twenty years or more.

They may buy a road scraper, and the supervisor may, if the electors at an annual town meeting shall so vote, purchase a stone crusher for the use of the town.

All male inhabitants of the town between the ages of twenty-one and seventy are liable to be assessed a road tax, to be worked out on the highways of the road district in which they live. There are certain commutations.

There is a cash commutation, also if a person takes down his highway fence where snow is liable to drift, he may be allowed the cost of taking it down and putting it up again. If he erects and keeps lighted a street lamp, he may be allowed not to exceed six dollars per annum for that service. If he plants shade or fruit trees along the highway he may be allowed on his highway assessment, one dollar for each four trees planted, up to one-fourth of the amount of his tax for that year.

No road may be laid through any orchard or vineyard, without it shall be declared necessary by a commission of three, appointed by the county judge, and they shall apportion the damages, and their proceedings shall be approved by the appointed judge.

There are certain fines for driving over bridges faster than a walk. These fines vary from one dollar to twenty-five, according as the span of the bridge varies from twenty-five feet to two hundred.

Any bridge whose length is two hundred feet or more, or which has any span of one hundred feet or more, need not be accepted and paid for by the town until it has been tested by the state engineer, and been declared to be a proper bridge, and built according to the contract. All bridge contracts are made subject to this provision.

Bicycles and tricycles are regarded as carriages, and are under the rules.

The country roads of the state of New York are about as bad as they can be. The soil of a large portion of the state contributes to make them so.

I need not describe to you the vicious results of the system of working out highway taxes under the direction of someone who ordinarily has no conception of how to make a good road.

Eli Perkins says, "The average farmer does not know how to make a good road, God never intended that he should." It seems to me that when roads are laid out, made and main-

tained under the supervision of skilled engineers, then we shall have good roads the year round, with scarce any more, perhaps even with less expenditure than at present.

FLORIDA ROAD LAWS.

S. C. HODGMAN.

To the Members of the Michigan Engineering Society:

I have been requested by your Secretary to give you some information in relation to the road laws in Florida. This is quite a difficult thing to do, as the state of Florida seems to guard her laws with a jealous care lest someone not of the elect should find out what they are and make hard times for the lawyers. After many trials I have succeeded in getting a look at a copy of the law of 1888, which was amended in some particulars by the last legislature, and have been told what the alterations were.

To begin with, in order to understand fully the law, a sketch of the system of local government is necessary.

In that system the county is regarded as the unit and all local government is subordinate to it. The county is divided into commissioner's districts. In this (Polk) county, consisting of about fifty-five townships, there are five such districts which are also subdivided into precincts for voting purposes, the precincts sometimes consisting of several townships. A form of election is bi-ennially gone through with which does not elect, but recommends the successful candidates to the governor for appointment. (This is in order to keep the darkey out). The commissioners form the county government—with some oversight from the county court. Local or neighborhood officials are few and far between. Even the common schools are dependent on the county board of school commissioners for everything—teacher, salary, length of term, repairs of school house, etc.

The title of the law is

An Act to Provide for Placing and Keeping in Condition the Public Roads and Bridges, and the Laying Out and the Construction of the Same, and the Raising of Revenue for that Purpose.

SECTION 1. Each county commissioner's district is made a road district. (Remainder of section repealed.)

SEC. 2. Repealed.

SEC. 3. Provides for the examination of roads and bridges, ascertaining the number of miles in each district.

SEC. 4. Shall advertise at least four weeks for contracts for keeping in repair roads and bridges, also "making, altering, working, repairing, fixing and constructing roads and bridges."

SEC. 5. "The working, making, altering, repairing, fixing and constructing" shall be let out to the lowest bona fide bidder by districts for one year, contractor to give bond, etc.

SEC. 6. Superintendent (commissioner) to personally examine from time to time all roads and bridges of his district—necessary work or repairs to be done at expense of contractor.

SEC. 7. Repealed. (Male persons over twenty-one and under forty-five, subject to work not less than three or more than six days.)

SEC. 8. Repealed. (Superintendent to furnish names to contractors.)

SEC. 9. Repealed. (Contractor to give notice of time and place to work.)

SEC. 10. Repealed. (Penalty for failure to work.)

SEC. 11. Repealed. (Justice of peace to issue capias for defaulter. May commute at 33⅓ cents per day.)

SEC. 12. County commissioners shall levy tax of not less than one mill or more than two mills on all real and personal property subject to taxation, as a road fund (and for no other purpose).

SEC. 13. All bills and accounts to be audited by board of commissioners, and paid by their warrant on county treasurer out of road fund.

SEC. 14. Pay of commissioners $2.00 per day (no extras).

SEC. 15. Same.

SEC. 16. All new roads to be on section or subdivision lines, or as near as practicable.

SEC. 17. Width of all public roads to be not less than twenty feet (no provision for sidings).

SEC. 18. Commissioner shall erect mile and "sign posts;" shall have roads graded when necessary by ditching and cross-waying wet and boggy places.

SEC. 19. Repeals all laws inconsistent, etc.

SEC. 20. This act to take effect on approval of governor.

It will be seen by this summary that there is no provision for a survey or record of a road—no provision for condemnation of lands for a route, and no provision for damages in any case. The lands of non-residents may be traversed in any direction at the will of the residents without redress, unless through the courts.

When a public road is desired by the residents of any locality, a petition, with as many signers as possible, is presented to the county commissioners, accompanied by a rough diagram giving a more or less approximate idea of the location of the road. No notice is given to non-residents or others interested. The commissioner for that district is supposed to examine into the matter and recommend, or otherwise, the laying of the road. If he reports favorably, the board declares the road laid out. If any damage is claimed the petitioners must pay it—the county will not - at least in this county. The commissioners seem to vie with each other in saving all the expense possible to the county, and the one who shows the least expense is the best man -- for re-election.

When the commissioner chooses, he can recommend the building of a bridge or crossway at the expense of the county.

There is something to be said in favor of this system as the country is now situated. Travel is not confined to roads except when the land is fenced on both sides, and it is expected that when the country is more thickly settled that new laws will be called for to suit the circumstances. I have an impression that in some of the older counties the whole matter of road laying, building and repairing is left with the county, and they make their own laws on that subject.

In case a person wishes to enclose his land through which a road runs, he can petition the commissioners to change the

route, which they will generally do, on a proper showing, unless natural obstacles prevent.

The improvements that I would suggest are that a system of main roads should be provided for, which should be kept on lot lines as nearly as possible, unless inconsistent with the best grade. Those main roads should be carefully surveyed and monumented, and a full set of field notes and a correct map of the same filed in the proper place.

That a county or district engineer should be appointed who is an expert in the laying out and construction of roads, and who should have the whole charge of the details of laying out and working those main roads.

That the whole amount of the highway fund should be expended on those roads, except, perhaps, what might be necessary for bridges on local roads. And when there is no necessity for removing obstructions on those main roads, the funds should be used for the improvement of the road bed by claying or otherwise, so that the result would be, in the future a complete system of good solid roads, mere local roads being left to the care of those who use them until the main roads are completed.

That the width of main roads should not be less than forty feet, of which at least twelve feet should be reserved for sidewalks. The road bed when made to be confined to the center of the road, and the planting of shade trees should be provided for.

Provision should be made for the condemnation of right of way and liquidation of damages where damages are claimed; also for written donation of right-of-way by a definite description of the land used for the road.

Provision should be made for the expenditure of the highway moneys in the localities where they are raised, instead of using them as a general county fund, to be expended where the interests of the commissioners may indicate.

The conditions of the highway problem are very much different from what they are in Michigan or any of the northern states. The soil is different. Heavy teams are not required for farm work and, as a consequence, are used very little upon the roads, nearly all the hauling being done with one horse or

mule, or by a pair of small oxen. Sometimes, even, one ox is used in a primitive cart. From four to seven hundred pounds is the usual load. As more northern, or *progressive* southern people come in there will probably be a demand for better roads. They will, bye and bye, begin to see how much time, labor and capital is wasted in going to town or coming home with a quarter of a load on the wagon. It seems but little now, but it will appear large enough when they begin to reckon it by the year.

I am inclined to think favorably of a "local option" in highway matters, so that more advanced counties can control the system best adapted to their needs, while the less thickly settled ones could use a simpler plan until a better one was needed.

I will not, in this paper, enter upon any discussion of the engineering problems involved, as they would not, probably, be of much, if any, interest to *Michigan* Engineers.

I take this occasion to assure you, gentlemen, of my continued interest in all your doings and that, did Providence permit, I would be very glad to meet with you again and to take my old acquaintances by the hand (but wouldn't my teeth chatter?). If I could be transported instantaneously, I would come loaded with flowers and fresh fruits for your delectation.

Haines City, Polk County, Fla., Dec. 16, 1892.

ROADS AND ROAD MAKING IN OKLAHOMA.

BY JOHN J. WATKINS.

A very brief description of Oklahoma may not be out of place before entering upon the subject matter of this paper, as indicated by its title.

Oklahoma, especially around and about Guthrie, the capital of this territory, is mostly a rolling prairie, interspersed with numerous small streams, many of which go dry, or nearly so, in a dry time, with patches of timber—oak, elm, walnut etc, lining the banks, as well as scattered in openings here and there upon the prairies.

Nature seems to have vied with herself in forming the beautiful landscape of this new country over her former efforts in the older settled countries or states. Its beauty is not one of awe inspiring, like craggy cliffs, lofty peaks or deepening canyons beyond the power of the eye to penetrate, but one that fills the whole soul with ineffable delight, awakening responsive chords in the soul's soliloquy—

"Here let me live, if live I may,
For many years while locks grow gray;
When parting time have bekoned me
On hill top lay, then shall I see
In rising at the trumpet's blast,
E'en grander sights than were my last."

Aside from the beauty of locations for settlements, the fertility of the soil is the great attraction of the many who are seeking homes here. Contrary to general expectation, the uplands in many cases are fully as productive as the bottoms; and for cotton and corn, are seldom inferior in quality and quantity of the crops, while much more easily broken up, and can be cultivated at all times, wet or dry.

The fertility of the soil is probably due to the complete admixture of clay and sand; the clays not being tenacious, but quite ochreous; and the sand without much grit, and largely devoid of gravel; in fact, you may in many places on the uplands chop all day into the earth with a sharp ax, and scarcely perceive the edge to be blunted or rounded.

On the opening of this country to settlement, home seekers whether afoot, on horseback, or in "prairie schooners," (covered wagons,) went or drove ad libitum in any and all directions; in consequence, roads were made cutting each other at all angles, because of the feasibility of traveling in the directions desirable and securing a good road, except when the streams and "draws" or ravines made it necessary to diverge from the chosen direction, and pursue a course along the side of the stream or "draw," to obtain a fording place over the stream, or a crossing place through the "draw" on a lower plane, where ascent would be less difficult.

Roads, it is very probable, over grounds in a state of nature were never found better in any state or country than in this

territory; in fact they are to-day, with all the immense travel and the heavy freighting from place to place, in very fair condition, except in siding places, or on the ascent of hills, with scarcely any road labor having been performed; on the places referred to with the constant travel and heavy freighting they become worn. After heavy rains, under such circumstances deep cuttings in these porous soils are inevitable.

In the old Texas cattle trails which pass through this territory, are to be seen cuttings caused by rain and travel of from four to eight, and even ten feet deep; of course the latter are on hill slopes; even in the city of Guthrie on the side ditches when there is much descent, in some streets the wash and cuttings have been made from ten to twelve feet deep; in fact from the looseness of the soil on account of its admixture, there is great tendency to wash and cuttings on all the traveled roads.

By federal statutes as well as territorial, all section lines are declared highways, and are being fenced out and worked some.

In counties and townships each, the highway and bridge tax, is five mills on the dollar; this while seemingly quite adequate, provides but a small fund, because so little of the land is "proved up," the title being yet in the government and not liable to tax; but the poll tax is four days or dollars per capita for all men not over forty-five, and from the fund thus derived, the most of our labor on roads is secured,

Every "draw" or ravine needs bridging as well as the streams; this makes a necessity for an ample road and bridge fund, while so little is available, consequently roads cannot be made as they should be, and the country is checkmated in its progress accordingly; but it does progress notwithstanding these disadvantages, and that "right smart," as the western or southern people say.

Each township trustee divides his township into as many road districts as he deems necessary. In this township, and generally throughout this county, (Logan,) they are divided into four, the same as the school districts, giving nine square miles to each district. The road overseer cannot charge for more than twenty-five days work, however many he may be occupied, at one dollar and fifty cents per day. In this district

No. 2, Guthrie township, having all the roads leading to and from Guthrie, with all the incoming and outgoing travel, heavy freighting to surrounding towns, log lumber, wood, brick, stone or rock, and sand hauling from the Cinnamon river for the needs and building up of this growing city, now over ten thousand, makes an outlay of from fifty to two hundred entry days necessary for the overseer with but twenty-five days pay. Great are the honors of overseer road district No. 2, Guthrie township!

Now for the second part of the paper, *road making*. The main travelled road from Guthrie to Downs, Kingfisher, El Reno, Reno City, and the newly opened country of the Cheyenne and Arrapahoe reservations, became next to impassable on the hill slope immediately west of Guthrie. This was said to be the worst piece of road between Guthrie and the before mentioned cities. By heavy rains and constant travel of four and six horse freighting teams, the wash had cut the road in fearful holes and trenches down to the bed rock, which underlies the surface soil from two to ten feet on many of such slopes. The road overseer of district No. 2, Guthrie township, started out to repair it, being in his district, and did it in the following manner.

The rocks that were laid bare were broken and picked off on the tops of some, others were blasted and the debris broken into sizeable pieces, the holes and trenches were partly filled or riprapped with this material; next small saplings and brush were cut in the adjoining timber and laid on this riprapping with the tops uphill, commencing at the top of the hill, making them shingle in layers one upon the other, care being taken to lop the branches so as to spread them in fan like shape when adjusted in the trenches. They were put into the washouts from three to four or more feet deep, as the occasion required, for nearly one quarter of a mile, the fills being from four to six feet wide, and as many feet above the ordinary surface of the road; these were weighted down with heavy fence posts, with occasionally a man or two's weight on top as the covering progressed to keep the scrapers from disarranging the layers. We commenced to cover at the foot of the hill, first with scrapers full of broken rock, then of earth; as the brush and

saplings became well covered and somewhat compressed, the fence posts, one at a time were removed *farther up hill*, and in this manner to the top of the hill, As soon as we had any part covered the travel was turned upon it so as to more thoroughly compress the timber and pack the other filling before the crowning of the road bed should take place. While the work of filling the trenches was taking place, other teams and tools were employed in plowing the side ditches. Most of the way it was soft rock, which with a heavy road plow with coulter, two or three men riding the beam and sufficient teams, we were enabled to plow some furrows; then came the scraping out; this was continued alternately plowing and scraping, till we had side ditches four feet deep and wider than deep. Where the rock was too hard for the plow, men with picks, crowbar, sledge drills and old axes, subdued the refractory portions.

After the road bed had been properly filled and ballasted with broken rock, came the crowning, which was done in the ordinary manner with scrapers, after which came the levelling and smoothing of surface of road bed. As we had no grader we were left to our other resources, and as the adage has it, "necessity is the mother of invention." We took the fence posts used for compressing the timber, laid them side by side as the pieces of a harrow with the distance of six or eight inches apart and chained them in such a manner; then in hitching to it with two span of large horses, one end or side was made to be in advance of the other about two feet. The two drivers mounted *this grader* standing up, and thus this road bed was levelled and properly crowned. Of course, it will be understood that these posts were made to run nearly perpendicularly to the line of the road way. What obliquity there was, was given it by running one corner in advance of the other as before stated.

Lateral ditches, quite shallow, were run diagonally from the road bed to the side ditches, so that no part of the road bed had to carry any water except what fell on its immediate surface, and that by the crowning was quickly conveyed by one of the lateral ditches to the side ditch. There were probably a dozen of these laterals on each side of the road bed.

This road takes all the travel westward from and to Guthrie, and has been in wear since last spring, and notwithstanding the present year 1892 has been unprecedented for very heavy rains with attending cuttings, still it has stood the test during this time without wear to any considerable degree, and only as might naturally be expected. From being the worst road in Oaklahoma, it is now acknowledged to be the best hill side road from Guthrie to the Cheyenne country.

This is one of three roads repaired or built in the same manner, all of which are doing good service.

Now comes the question, why commence at the *top of the hill* and shingle the young saplings as set out? Because the waters that may run upon the road at the upper end, will after seeping through the earth to the timber, follow the timber to the riprapping below, and then will course through the stones till lost in the earth, leaving all the material above the riprapping in place and the whole structure remains solid. But had the fill from the saplings been made from the lower end up the hill, every rain would have laid bare the lower part of each course of the filling, and made just so many places for the water to ooze out and widen the old cuts. It should be observed that the riprapping on the road bed before the crowning caused the crown surface to dry out very much sooner after each rain, and tend to solidify the road bed as well as its preservation, enabling it to resist the heavy pressure of the freighting teams.

January 1, 1893.

GENERAL STATUTES OF NEW HAMPSHIRE —MAKING AND REPAIRING HIGHWAYS.

RAY T. GILE.

1. Towns shall annually raise such sum as they judge necessary for the year, to be assessed and collected as state taxes, for making and repairing highways and bridges therein.

5. Towns may choose as many surveyors of highways as they think proper.

6. If none are so chosen, the selectmen shall appoint surveyors.

7. Surveyors enter upon their duties on the fifteenth day of May.

8. On or before May 15, annually, the selectmen shall limit the several surveyors' districts, and give to each surveyor a list of the persons in his district, with the highway tax against each, and a warrant to collect the same.

9. Every surveyor shall give to each person named in his list, or leave at his abode, a notice of the amount of his tax, and of the time when, the place where and the tools with which he shall attend to work out the tax, four days before the day appointed, and may require any person to work out not more than one-half his tax in labor of animals.

12. The town may determine the prices to be paid for labor, materials and use of tools applied in working out the taxes; if not so determined they shall be fixed by the select men.

13. The surveyor shall allow to each person attending to work out his tax, the time necessary to travel from and to his home.

17. If the highway taxes in any town are insufficient for the suitable repair of the highways and bridges therein, the selectmen may cause them to be put in repair at the expense of the town, but not until the money raised by the town has been expended.

24. Highway taxes shall be paid in money, when the town, at the time of raising money for which the tax is assessed, so

direct; and such taxes shall be committed to the collector, and when collected shall be expended in repairing the highways, by the selectmen or surveyors of highways, as the town may direct.

27. Towns may, by vote or by-law, authorize their selectmen to contract for keeping their highways and bridges, or any part thereof, in repair for a term not exceeding five years.

37. Towns are liable for damages happening to any person, his team or carriage, traveling upon a highway or bridge thereon, by reason of any obstruction, defect, insufficiency or want of repair which renders it unsuitable for the travel thereon.

Highways not in any town or place liable for the repair of highways shall be made and repaired by the county; and every county shall be liable, as towns, to individuals and to the public for neglect therein.

F. HODGMAN,

Dear Sir: Many of the towns in New Hampshire still cling to the Highway District system in the repairing of the county roads.

In the town of Littleton the farmers are unwilling to adopt a new plan. It is customary for the town to raise one-fourth of one per cent of the total valuation each year for the repair of highways. The inhabitants of the village have tried for several years to get the town to adopt a better highway plan; but failing in that they have recently had the village set off, by the action of the state legislature, into a separate highway precinct.

It is proposed to begin the use of broken stone on the streets. I think, in time, the farming community also will be led to see the advantage of better roads and be willing to help pay the expense of making them so.

In our town, this year, outside of the village highway precinct, the highway tax was raised half in money and half in labor.

Littleton, N. H., Dec. 27, 1892.

RAILWAY AND HIGHWAY.

H. E. RIGGS.

The last three or four years have seen a decided effort on the part of our citizens to secure better public roads. Engineers have discussed the matter more thoroughly, and it has been brought to the attention of the public at large as never before, through the medium of newspapers and magazines.

It does not require much of a student to get at the point of the statistics. Good roads pay, and they pay well. It would be the greatest godsend to the people of this country could we have such a system of roads as France possesses. The stagnation of business in our smaller towns in certain seasons of the year would be greatly reduced; the farmer would be enabled to reach the markets with his produce at all seasons; and he, as well as the consumer of his produce in the cities, would be financially ahead.

I have been asked to say a few words on the relation of the railroad to the country road, and have also been asked what, if anything, the railroads should pay towards the cost of improving these roads?

If I may be permitted, I will lose sight of the term "country roads," and give a few remarks on the relation of railways to all roads crossed by them.

That railway companies suffer a loss of revenue on account of the villainous dirt roads and narrow tires in use on them, I do not question.

I do feel that it would be impracticable and impolitic to call on the railway companies to contribute a sum of money to be expended on highways under the direction of any such road officials as we can at present boast. A railway company has so many items of expense which are outside of the cost of the maintainence or operation of its road, and its relations with the people at large are frequently of such a nature, that any demand for additional taxes, and particularly for such a use, would be met with refusal and with long continued opposition in the courts.

It is to be regretted that the relations between railway managers and the people are not as harmonious as they should be. There has been a tendency on the part of demagogues and politicians, in order to gain a certain kind of petty notoriety, to raise the hue and cry against railroad companies. Newspapers have taken up the cry, and have aided in creating a popular feeling of distrust and enmity toward this class of corporations. I think that it is the farmer who is most suspicious of the railroad companies. I find this spirit of distrust most strong away from the cities.

This state of affairs should not exist. It has led in some states to legislation alike ruinous to the interests of railway and state.

Permit me to quote from a recent report of the railroad commissioners of the state of Kansas:

"It is believed by the board that questions of paramount public concern enter into the business of railway construction and management; questions of statesmanship most difficult to master with justice to the public and the companies, a solution of which can never be successfully reached without a recognition, as a fundamental fact, that public and corporate interests in this relation are so completely identical as to involve the prosperity or adversity of each in that of the other. They are moulded from common element of mutual interest and dependency."

The railway companies are closely allied with the people in their efforts to build up a state, and they share the burden of taxation; they open up remote districts to settlements; they are makers of cities.

I think I can safely say that the manager of every line of road in the country will join most heartily in any effort to build up any county or city through which his line passes. He will do so from exactly the same motive as would influence any other business man, awake to the best interests of his business.

There is one feature in the relation of railway and highway that is of highest importance, that involves an annual expenditure of much money and an annual loss of many human lives. That feature is the *crossing*.

You will all admit that a railroad crossing your highway at grade is an element of great danger. It is particularly so, if

by reason of obstructions a clear view of the tracks cannot be obtained.

A glance at statistics will show that more lives are lost every year at grade crossings than are lost in what is supposed to be one of the most dangerous of occupations, that of coupling cars. More people are killed annually at grade crossings than are killed while riding as passengers on trains.

The following figures taken from such of the Michigan reports as I have will bear me out in this statement:

Date of Report.	Killed at R. R. Crossings.	Killed Coupling Cars.	Killed Passengers.
1886.	8.	11.	2.
1888.	19.	10.	7.
1890.	29.	24.	7.
1891.	26.	8.	5.

This shows something of the need of proper protection of life at these crossings. From the commissioners' report just issued I see that there are in the state, 7,493 road crossings, of which 211 are either overhead or under crossings. Of the grade crossings 495 are protected by flagmen, gates or automatic signals, while 6,998 are unprotected except by the sign board required by law.

The loss of human lives as shown in the reports given, in all probability represents a large expenditure in settling claims. During the same years nearly as many people were injured at crossings- another probable expenditure for damages.

I believe that it is for the interest of railway companies as well as of the public, that these crossings be protected. Where the crossing is in the country, the view unobstructed and no extraordinary travel on the roads, the sign board required by law is generally sufficient. In towns and cities where there is more travel on roads and more general use of tracks by engines and trains, some means of protection should be afforded.

The best, in fact the only certain means of protection is the total abolition of grade crossings at important points. There are few, if any, railroad managers in the country who would not heartily wish that *all* grade crossings could be abolished. It is a pleasure to know that many roads are mak-

ing this necessary improvement as rapidly as possible in the cities.

The maintenance of gates, with the necessary attendants or flagmen, is costly and unsatisfactory. Hardly a week passes that our attention is not directed to some accident at such a crossing. In Chicago a few weeks ago eight or nine lives were lost by a street car being struck at a crossing protected by two flagmen. Parties using the road take greater risks at these so-called *protected* crossings than where there is no protection but the sign board.

I should favor an effort to secure the co-operation of the road officers and railways, and let the railways pay their share of highway improvements in the erection of substantial viaducts at all main arteries of travel. Let the county or township grade and pave the road and approaches to the viaduct and ask the railway to provide the bridge. When done your road will be safe and a matter of pride to all.

To summarize briefly: 1st. Any laws passed and put in force, that will tend to improve the highways, increase business and afford constant access to the outlying districts, will be of benefit to the county and state, and as a natural result cannot but be of utmost benefit to the local business of the railroad companies, owing to the close relations and mutual dependence of public and railway interests.

Secondly, The railways can best aid in the construction and maintenance of these roads by abolishing, so far as possible, grade crossings at the main arteries of travel. I do not think that any special road tax should be levied on the railroad companies, but an effort made to secure their co-operation in the erection of viaducts, and have the railroad proportion of expense levied in this way.

THE RELATION BETWEEN RAILWAYS AND PUBLIC HIGHWAYS

AND HOW CAN THE RAILWAY COMPANIES BEST ASSIST IN THE IMPROVEMENT OF THE PUBLIC HIGHWAYS, AT THE SAME TIME FURTHERING THEIR OWN INTERESTS?

E. FRENCH.

In the recent discussions regarding "better roads" it is not unusual to hear the opinion expressed that "all the freight will eventually reach the railways regardless of the condition of the highways." This, I believe, will not be true so long as corn is used for fuel in the west, straw and other products of the soil are burned all over the country, and forests are left standing for want of facilities for transportation of the product.

The relation between each particular railway and the highways in the region through which it passes, is dependent upon so many and such diverse circumstances that each must be in great measure a law to itself, and we can hardly do better than to consider briefly some of the circumstances under which railways might reasonably be expected to aid in the improvement of highways.

1st. In the case of a fertile district or town lying about midway between two competing lines of railway, where the improvement of the highway leading to one of the lines might secure to it the bulk of the traffic from such district or town.

2nd. In towns where there are two or more lines of railway, the one whose depot is farthest from the business center may secure the bulk of the traffic by a judicious expenditure in the improvement of the highways leading thereto.

Although these are special cases, they are the ones that railway managers will insist upon having attended to first with the means they are asked to appropriate for the purpose. They will also insist that none of the means appropriated by them shall be used in increasing the facilities of their competitors.

While they will admit that the *general* improvement of highways will make a considerable accession to the earnings of their

lines, they will hardly consent to join voluntarily in such general improvement for various good reasons.

1st. Uniform voluntary action (if desirable) would be impracticable.

2nd. The benefits accruing to the railways would bear no adequate proportion to the benefits accruing to farmers in the increased value of their lands, to say nothing of the decreased animal power required to carry on their operations.

3rd. We in Michigan can hardly say where a through trunk line could spend money on the improvement of highways to the best advantage of itself, for although these lines may pass our very doors in Michigan, is it not possible that the condition of the highways in Kansas, Nebraska or Dakota may affect their interests much more vitally than the condition of highways at any point within our own state, upon the same principle that the advertising matter of a railway is generally distributed upon other than its own lines, or that agents are allowed commission on tickets sold over connecting lines?

Again, railways as public servants are obliged to keep constantly on hand the facilities necessary to move the traffic that comes to them, and in general any measure, such as the improvement of highways, that will cause this traffic to flow in a more uniform stream must have the effect to enable them to handle it more cheaply than when it comes in floods followed by corresponding periods of depression.

Yet Michigan is peculiarly situated in that the trunk lines passing through her territory derive the bulk of their through traffic from the region naturally tributary to the great lakes, and are crowded with business during those months when navigation is closed; and this usually is the time when highways in Michigan are at their worst, and the local traffic is depressed accordingly, while the through traffic is at its height. This, of course, is as this particular class of railways would wish to have it, as a congestion of business is inevitable with them in any event, and the improvement of the highways in Michigan would, in my opinion, tend to further complicate the matter.

In conclusion, I can see no way in which the co-operation of railways can be secured in this matter, except by the usual methods of assessment or taxation.

LEGISLATION FOR BETTER ROADS.

GEO. E. STEELE.

The legislature is invoked whenever anything goes wrong in the economy of the state, even to attempting to make men temperate. A large part of the precious time of the law making body is taken up in changing the name of Miss "Fide Bona" to Miss "Bona Fide," and such like, of vast import. It may be readily guessed, after making these startling statements, that we are not of the class which has implicit confidence in the legislature at once setting us on the macadam road to glory, all in the "one horse shay." Revolutions do not come by the flirt of the executive pen—except in South America. We must be content to ask the legislature to do the very best it can, as quick as it can, for the *patient* is *very low*. We must then hold up our hands and promise to do our part. Then the era of good roads will begin to throw out a faint light in the East—following it, the clear day.

It need not be expected that the legislature will move far in advance of public sentiment; and this sentiment is not at present educated up to the point of demanding good roads. Some are taking advance ground, and the subject is having general attention, but the most of our people do not realize how much is lost by bad roads. They easily fall into the ruts of "well enough," or "cost too much." Although we are somewhat behind some of our sister states, we are vaccinated, and will in due time break out with "road rash."

This period of organization must precede all else, as well in road building as in other lines. The legislature is handicapped by the constitution, which prevents it from vacating or altering any road laid out by the high Commissioners of Highways.

Article IV, Section 23, and under 11 Michigan 155, and 20 Michigan 95, confines this action to state roads, by delegating the power of Boards of Supervisors. Also by Article XIV, Section 9: "The state shall not be a party to, or interested in any work of internal improvement, nor engage in carrying on

any such work, except in the expenditure of grants to the state of land or other property."

Under this it has been decided, "that township, highways, and other local interests cannot be taken from the custody of the proper local officers." This makes the highway commissioner the *sine qua non* of township roads, or to translate the Latin, he is "Big-Injun-Me."

See also 15 Michigan 347, and 34 Michigan 46, where the commissioner is given full power to lay out, alter, or discontinue highways. I cannot here enter into a discussion of these constitutional restrictions. Whatever may be done to make the constitution a help to good roads, must be preceded by a thorough school house campaign of education, or the amendments will be killed by popular prejudice. In view of such misleading error, I believe more can be accomplished if the legislature does not at first attempt too radical changes. I admit that most radical changes are needed, but we are not to expect suddenly to emerge from the "corduroy" road to the "Appian Way." Then, in my judgment, such a plan should be adopted as would, by increasing public attention and appropriate legislation, gradually bring us into better condition.

Let us map it out.

1. Preserve the township system with some modifications for local or unimportant roads.

2. By a local option plan provide that any county may set in operation a county system with three county commissioners, who are distinct from the board of supervisors, and who shall have power of location, construction and maintenance of the most important thoroughfares. If these were treated as "State" roads, they would, under present decisions, be free from control of the township commissioner.

3. Have a county engineer who shall locate all town and county roads in conjunction with the officers named; map carefully all roads, set out work for contractors, and see that their work was properly done.

4. Do away with all building of roads by the state at large, and make the laws we have, so far as applicable, to conform to new county system.

5. Provide that by vote of the people of any county bonds may be issued, guarded by such low rate, long time, and provisions as would seem best. This money only to be used for a few important roads.

The modifications of the town system would be mainly as to the power of the commissioner to locate or alter highways. There is no check on this officer. He lays roads in the most hasty manner, and sticks to the section lines if they are well nigh impassable. We have lost enough by this poor policy already in state roads and highways, to have built a stone road the whole length of the state. As a surveyor, I have been called upon to make such locations as I knew were not best, but had no power to do otherwise. A road should be located by a capable engineer with as much care as a railroad, (permitting heavy grading,) and with curves instead of abrupt angles, all being thoroughly monumented. Authority should be given in this direction, and also to alter roads laid out so as to improve them. We would then stop expending money where it was worse than thrown away. Such poor locations are expensive luxuries. By proper application certain portions of roads already laid out could be condemned, these portions thereafter to receive not one dollar of public money. The new and best location would follow as a matter of course. The older parts of the state have their roads located, except as improvement of location could be made. But it must be remembered that, over say one-half of the state, new roads are being constantly laid out, and this will continue for many years. The question of location then becomes the very foundation of all subsequent expenditures, and should be committed to those best capable of giving it attention, free from local bias, and who make this work a study. This would be expected of the county board and engineer. It would be an advance to brush the dust off from the county surveyor and make an engineer out of him. The office is now of no consequence, and by making it the "Hub" of road construction, would be filled by men chosen with this in view, and become something besides an empty name. As to the state taking up the road building, it would seem that the day is passed. We have no use for long military or other roads. The railroads take the

place of such. We have already seen the misappropriation of hundreds of thousands of dollars in state road building, and if these are samples of state construction then deliver us from any more. County credit should be as good, or better than the state. The former cannot repudiate, the latter can. Those counties where first-class roads are built will find their credit thereby improved. Other counties not moving in the matter will retrograde.

DISCUSSION ON ROAD LAWS.

MR. HODGMAN: I don't think we want any state roads. I do not think any road would be of sufficient consequence to require the state to build it. When the time comes for such a thing it will pay to build a railroad, and when you have the railroad you do not want the state road. So I would divide our roads into simply two classes, county and township, or neighborhood roads.

For the support of the county road I would levy by statute an uniform tax of some reasonable amount, say perhaps, one mill. That should be devoted entirely to the work of building and maintaining county roads. I would levy by statute another tax of one or two mills, or whatever sum would be reasonable, for a township tax, to be paid in money for the support of common township roads. I think in the township of Climax we assess about one dollar for every eight hundred dollars of valuation. Suppose we make it two mills. That would be plenty, but I would adopt some fairly reasonable sum to be spread uniformly all over the state, both for the support of county roads and of township roads. If any sum greater than that was needed for the support of the county roads, it should be laid before the people of the county to vote upon, with detailed estimates. The persons who have the care of that should make a report to the board of supervisors of what road they propose to improve, the manner in which they propose to improve it, and the estimated cost; and that should be submitted to the people for their vote at the next election.

In the same way, the township roads should have a mill tax for their support. Make it a minimum sum. The person who

has charge of the township roads should make his report to the township authorities, showing what has been done during the past year, giving itemized statements of it in full, of what money has been expended, and the whole thing, so that every person in the township may know what was done with the money. If anything in addition to this mill tax was needed, require him to make a specific estimate to lay before the people of his township, stating what improvements are needed and the estimated cost, and let them raise it if they want to. In this way we keep the whole question of taxation before the people themselves to settle.

I would authorize the putting of tramps and vagrants to work on the road; authorize the highway commissioner to purchase the right-of-way for highways, at a price not exceeding the market value of the land, and in case he could not purchase it at that price, to call out a jury to condemn it. I should require a complete and accurate description of all road lines, whether now in existence or to be laid out, to be filed in the office of the register of deeds and in the state land office.

Country roads sometimes grow into city streets, and it is a very difficult matter to determine just where the location of that street is. I would require that these roads be established and monumented. There should be a permanent monument at every section corner and quarter section corner, and at every angle in the road, and a thorough description made. I would fix a suitable fee for recording and pay it out of the general tax I speak of having levied, both in the case of county and township roads. I would make the road laws apply to all platted streets outside of incorporated cities and villages. I would fix a penalty for destroying or removing monuments made to define road lines, and provide some manner of enforcing it. I would provide that all county roads should have permanent grades adopted; would have all heights of the county roads referred to a common datum, and if a road was on a county line, would have an established bench mark at the county seat, to which all heights should refer; show the heights of every railroad crossing; show the heights of the surface of the water in every stream; require it to be *done, by law.*

I would require all work done in constructing gravel and paved roads to be done by sections of some specific length, according to detailed specifications; and in case done by contract, not to be paid for in full until the specifications were complied with. I would require all graveling and paving to be completed to the grade as far as they go; adopt the grade first, gravel it as far as they go and finish it. If a road has to be plowed up, let it be but once. There might be exceptional cases where that might not apply.

I would furnish every highway commissioner with a good text book on highway improvement. I think we have people in our society to get up just such a book—some little book that, without taking much space, would go right into the fundamental principles of making roads and bridges, simply common short span wooden bridges and culverts, and giving specifications and put that into the hands of every highway commissioner.

Now we have lots of highways in this state and everywhere else which require drainage. In certain classes of roads, clay roads especially, the most important thing is to have thorough drainage, and it is necessary to go across private property oftentimes to secure it. Hence, I would authorize the opening of watercourses across private property and provide a manner of condemning for right-of-way.

The only change I would make in the constitution would be to abolish the office of path-master and to extend the time of the highway commissioner. I would retain our present highway commissioners. I would organize a county board of highway commissioners to consist of the commissioners of the several townships. I would give to that board of highway commissioners the general control of all county roads; they should determine what roads should be county roads and what not, and authorize the expenditure of all the county funds under their direction; authorize them to employ competent road makers to supervise it.

I would require that board to make an annual report to the board of supervisors in detail a report of all money expended by them, and where and how expended, and estimates of all improvements requiring additional money to be expended.

I would require each township commissioner to make a full report to the county commissioners, and the entire report to be consolidated and filed with the county clerk and in the office of the secretary of state.

These are the leading points I would suggest for the improvement of our highway laws. I do not think we are ever going to get any highway laws that will be perfect. It is going to be a question of time; there isn't any system that is perfect. I have corresponded and talked with engineers in other states where they have the county commissioner system, and there are grave evils connected with that. There is no perfect system, and you will never get such a one until you get a system that will put in office none but thoroughly competent honest men, men who will not be prejudiced, and they are so scarce we shall not get many. There will be no perfect roads until we get more perfect execution of the laws.

MR. HUBBEL: When I came into the Convention, I thought perhaps I had a few ideas on road making, and I flattered myself that perhaps some of those ideas were original, but after listening to the papers that have been read, I find that nearly all those ideas have been presented, so that my original ideas are mostly second-hand, and for fear that somebody will tell all the rest I know, I thought I would begin the discussion at this point.

The first point I shall make is this: We are often told that if some system of road making had been adopted twenty-five years ago and had been followed up, that by this time, we would have a splendid set of roads. If a system of making roads had been adopted in Michigan twenty-five years ago, and been followed up, we would have wasted three-quarters of the money put in. That is what I think about it. In fact we have wasted a large proportion of the money put into roads, and that waste has not been entirely because misapplied or not well done. The fact is, that the road problem in Michigan has changed, and the roads needed twenty-five years ago are not needed now. Years ago it was supposed that we needed state roads. They are of very little use to-day, and not because they never were made, and because many are not well laid out, but because we have no use for them. Men do not start out

to-day and travel thirty or forty miles on the common roads. Years ago a franchise might have been valuable, granting to a company the right to build a road from Lansing to Grand Rapids. To-day, a company would not think of accepting such a franchise.

So the necessity of to-day is entirely different from the necessity in years past, and the principal cause of this change in Michigan is the construction of railroads. People now want to get to the railroad and get there the shortest way possible. In place of laying roads from one town to another, we want a system of good short roads, all of which terminate at the railroad depot. Of course there are exceptions, but if you make a good road, or a good system of roads terminating at railroad depots, you will supply seventy-five per cent. of the necessities of the case.

Now, with this in view, any system of roads that you see fit to recommend, in my opinion, must take fully into consideration the fact that the travel is now by rail, and what we need are short roads, and roads ending at railway stations. Our roads want to be simply an extension of our railroad facilities.

It seems to me, that the only place we can begin to build permanent roads with the reasonable assurance that they will be useful for years to come, is to begin short lines at our railroad stations. The railroads are in the nature of a permanent institution, and the business is going to continue.

As for the classes of roads, I should think we need at least three. I think all classes should be upon some system, and have some specifications. I would have a first-class road, which is first-class in every respect - broken stone, or at least gravel. A second-class road which is also a good road, and a third-class road, which consists of ditches, and the spreading of the surface soil to support the road. By improvement it can be made a second-class, and by still further improvement, a first-class road.

We have heard some of our friends say, that the railroads would not do anything; that is the fact, if you tackle them in the way that was perhaps intimated by the paper.

The railroad will say: "We have built our railroad, and have opened up this country, and somebody else ought to

build the roads to reach the railroad." And still they are deeply interested in having these roads terminate at their stations. There is a way of enlisting the railroad corporation. I think the railroads would take the contract to build these roads - these short roads leading out from depots, and to be let under contracts and specifications. Nearly all railroads have a construction company, and if the railroad itself would undertake the contract of building these roads, I think the construction company could be induced to take the building of short roads radiating out. I would limit these short roads to three or four miles. I think in justice to the railroad, that a portion of the railroad taxes ought to be applied to highway construction. There might be a constitutional defect in that, but no matter about that, if it is just and right and proper, and the will of the people, that could be overcome in time. The railroads of the state, you are aware, pay no taxes to the township or county, nor do they contribute anything for the support and maintenance of the roads. They pay their entire tax in the shape of a percentage on their earnings. The amount of money paid in by the railroads last year, as taxes, was nearly a million dollars. This is put into the state treasury. The people of the country naturally feel that the state has taken from them the power to tax the railroads, and all the benefits to be derived, so far as immediate neighborhood benefits are concerned. Now, if one-half of the money paid in by the railroad to the state as taxes could be applied to the public highways, could be applied to a good system of short roads leading from railroad stations, it would be a very satisfactory arrangement, I think.

I believe it would be satisfactory to the railroad company as well as to the people. This would not be contributing in the sense of the paper read here, it would be allowing a portion of their money to be used for an improvement that would be a benefit to them. Now the exact way to get at this is probably a problem for some one better versed in legislative matters than I; but I think it is an idea that would be the beginning of the making of a system of good roads, starting from railway stations and emanating thence. This would be only a commencement, but if followed year after year, would soon amount to

considerable in the making of good short roads, which would be, you might say, examples. The people would see the benefit of a good piece of road and get an idea of the cost, and be induced to continue these good roads as far into the country as was demanded.

I would have these roads constructed, if possible, under the supervision of the engineer of each neighborhood. I know it has been said that the opening up of a new system of roads would make a good deal of business for engineers; this may be true, but the railroad can lay out and plan this work a great deal better than any independent engineers could be deputized and made to do it. I think the railroads would take the contract for building these roads cheaper than it would be done by anyone else. The railroad would haul gravel or would take the building of the whole road upon itself, if the bill for so doing, properly audited and approved, would be received at the state treasurer's office as so much of their taxes. It is simply enlarging on the old system of a man working out his taxes, and I think it could be made to work.

MR. GARFIELD: I came here to listen; I knew you were going to discuss roads, and I am greatly interested, and I wanted to see what this body, that I feel has more influence than any other one body, would say. If I can say just a word to show my interest, that is all I desire.

The growth of road building in our country thus far is a work that has not gone very far, and still I am not at all discouraged about it. I am more encouraged to-day than six months ago. I felt when this discussion began to take its new direction during last year, that we were just about as badly off as we could be with regard to roads, and whenever the question as to the betterment of them by some local legislation, came up and was defeated, I felt we were in a discouraging condition of affairs. But after spending nearly five months on the other side of the ocean, and looking into their systems, I felt encouraged, because I found the very best roads I traveled over were begun 1800 years ago, were founded by the Romans in their progress north. The very best roads in Switzerland are on the lines laid out by the Romans and added to from that day to this. We haven't lived but a little while, and all Europe

is small compared with us, and if we can only get a start in this century I shall be content. I think what has been said about railroad building is true. Road building has had a set back from the rapid increase in railways. I was glad to see one thing in connection with Switzerland roads. Two faults with regard to Michigan road building have been, first, that we thought we had no good material to make roads of, and when we found we had, people did not take advantage of it and find the places where the material was in abundance. The very best roads of Switzerland are made of gravel—not McAdam, but gravel. It is such as we find in our drift, and it is drift material such as ours, only it is a little closer to the fountain head. In the streams running away from the glaciers, it is rounded off and left in piles, and you find quantities of about the same size, and they shovel that into their carts, and take it as they find it. We have the same material scattered all over the peninsula of Michigan, if we only find it; but the great mistake has been, even after they found these gravel pits, that they took it just as they found it, instead of screening it and taking only that which was best. The gravel there is screened. Here, if we find a gravel pit that has enough sand, we think we are exercising economy if we put it on the road with the sand in it, and we have a road not much better than before.

I once belonged to a little grange that was organized in our township, and we met at two little school houses. The road between those two school houses disintegrated our grange. It was too hard work to get over that four miles of road, and the result was our grange broke up just on account of that miserable piece of road between the two school houses. Upon the remains of that grange a gravel road company was organized, and they put a toll road by there, and there are two results of that road to-day. One that the property along that road for six miles, while other farm properties have been greatly lessening in value, has increased from twenty-five per cent to forty per cent. Then too, an example has been set with regard to the use of gravel. That road came over a hill made of gravel and sand, and no one ever thought it could be made a good road. It was the hardest piece of road in our county. All

this company did was to screen out the sand and they had a perfect road-bed. That single example was worth more in the road districts than anything that ever happened before. And so I preach, with Mr. Steele, the value of missionary work.

Just how, by legislation, to get those examples of excellent pieces of road before the people, I don't know, but it is the one thing of all others most needed. If we can get a single line of good road in every county, in every state, we shall have the whole thing settled, because we shall have everybody with us.

Six months ago, if anyone had said, "You will be a bicycler," I would have called him – I would have said he was very much mistaken. In the twinkling of an eye I was converted to bicycling; and there are lots of people to-day that are opposing any change in our system of roads, who stick and cling to that old path-master system, that will be converted in the twinkling of an eye, if you can just make a good economical road near them. I hope that whatever legislation we have, we shall not undertake too much, but get some object lessons before the people. That one thing will soon convert them from the most pernicious system that ever was. It was good in its day.

One other thing has occurred to me with regard to specific taxation. Now, the objection you will meet everywhere, in submitting any plan to the people, the majority of farmers will object to any innovation because they are afraid of an addition in taxation. I have met that everywhere. Now, if you can adopt a system by which they will get good roads and not pay any more taxes (I mean outside of the taxation they never feel), if you could show them that in a year they will not pay as much taxes as they do now, they will be willing to adopt any kind of system. That is why I like the idea of a state tax that shall be paid by everybody, rather than one paid by the farmers themselves. While it is true that the more immediate benefit is reaped by the farmers themselves, still every man that buys a bushel of wheat or a pound of flour will be benefitted by better roads, for immediately when you reduce the cost of putting these products in the market to a minimum, you are helping every man that has to buy, and there is no injustice in making every man bear part of the taxes.

Farmers do not realize as they ought, one thing. We must, in some way, turn the trend from the cities into the country. I think that that is the most important question before our country to-day, how to do it. The gradual decadence of agriculture in this country has tended to throw the people into the cities. Let us get them back again some way; and there is no motive power that will be stronger than the building of good roads and making country life attractive. The one thing necessary is to make country life attractive to people and they will go there; and one of the most essential things is the interchange of visits and thought. And just as soon as you get good roads, you will bring people together, and country life will be attractive.

In regard to specific taxation; it seems to me, aside from this one thought, making everybody pay their proportion, there may be something in the English system of taxation, special taxes for those who use the roads most—every man who goes over the road with a vehicle, whether wagon, buggy or bicycle, it seems to me can pay something for the privilege of good roads, in addition to that great number of people who simply get an indirect benefit. I am interested in this discussion, and in this earnest endeavor to get better roads, and I believe that the engineers of this country must do more than any other organization, because you know how to make a road and make it economically; and it is because your services have been neglected that we haven't good roads.

THE PRESIDENT: We are glad to have these ideas that Mr. Garfield has so ably presented, and glad that the farmers are taking hold of this question. The engineers of the state have understood the necessity for good roads for a great many years, but whenever they have attempted to advocate anything of the sort, it was thrown in their faces that they were simply looking for a job, but now that the people themselves are taking it up, we can hope for some legislation.

I have believed for many years, that the great evil of farming life, was the want of those social enjoyments which the human mind must have. It is that which has been driving all the young men and women from the farm into the city, and crowding our cities, and which is sending so many of our

farmers' wives to the asylum. Get good roads, and as Mr. Garfield says, the current will begin to set back. Men living now on small wages in the city, will go back to the farm, and have all the social enjoyments that he would have in the city.

MR. STEELE: I do not come here to discuss this question in any sense, as an instructor of the engineers of Michigan, as to road building. I come before you as one to lift up a voice in the discussion of the question as a matter of public interest, hoping that whatever our discussion may be, it will be conducted in that spirit which shall make it the most valuable and useful to those in interest.

It may be claimed that the engineers are looking forward to do something in their own line: Very well, if we do not tend to our own business, I do not know who will do it for us, and I want to state my position, not so much in the discussion of the law side of the question, which has already been mentioned, as the practical side. We are passing through, or perhaps commencing, one stage of education in road making—not exactly in road making, but a preparatory course for road making. We are not ready even to make the roads yet. Hence, the first thing I would mention is education. Educate everybody - talk it over, publish all you can about it, keep it going; if you do not succeed at one time, strike fire somewhere else, and persistently put this subject before the people until they rise in arms, and accomplish what we are after. I would like to have the determination of every member of this Society so fixed in that line, that no matter what discouragements are met, mis-legislation, or wrong course of action, they will still go on and accomplish the desired result.

The first thing I would put down is education of ourselves, and people in general. You may start out in the state of Michigan to-day, and ask those you meet outside of the cities—I say outside of, because usually in the cities they find the advantage of nice streets and pavements, which the rural communities do not have and appreciate, or think they cannot have, and you make a note of those men you converse with, and you will find the difficulty is, that they are opposed to any movement at all. They are afraid of everything—do not want to take a single step forward in this matter. You may present

an amendment to the constitution to-day, in the way of bringing this result nearer, and they will vote it down here in Michigan. Why? Because the people are not educated yet to see the necessity, or they do not fully understand the rut into which we have gotten. The education then should be begun of the people, broadening their views through our papers, through every channel, through the societies; and let me say right here, I have understood that some of the societies, or one of the leading organizations of the state have cast a reflection on the wheel men, saying that they were the prime movers in this work, and that the subject was not worthy of our attention, because of their moving first in the matter. Now this has come to me through good solid, straight-forward farmers. Wonderful, isn't it? I said to the man who told me that, "I would give credit to the d——l, if he only started people thinking about the system we have. I do not care who starts the subject if the ball is only set rolling."

Now we have another phase on this subject, not already mentioned. That is the need of the engineering profession to be prepared for the emergencies which they constantly meet. It has been suggested that our schools be transformed into great classes of students learning how to make highways; that we have schools of technology, with a special department which shall have professors etc., to illustrate how to make a good road. Now, I have no objections to raise for any such course that will more enlighten the people, because I have already planted one stake—my educational stake, but I say that it is assuming too much to claim here, in this early stage of the construction of roads in Michigan as they should be constructed, that the engineering profession that we already have, the gentlemen that I see before me at the present time, part of them, that we are not capable of taking the responsibility of road construction without more special education on the subject. It is rather a laughable situation, when we know that you gentlemen are engaged in the construction of all sorts of engineering works, railroads, bridges, tunnels and river improvements, and all classes of engineering work which tax the highest skill, yet it is suggested that the engineering profession needs special schooling to make a highway. I deny

the imputation. Is it not a fact? I will assert boldly that the engineering profession is able to take care of the highways, if only afforded the opportunity.

The next stake that I would plant most substantially and thoroughly, is for the location of the road. After having arranged all our preliminaries— how we are to get our money and change our laws--the next thing to do is to know how to locate the road, and that is just the very thing that we have not known how to do. I want to give a few of my experiences in locating roads.

In 1867 I surveyed the state road from Houghton to Midland. It was then a wilderness. We had to carry our provisions on our backs. Our whole expenses were to be paid by the counties through which the road was laid, and the bill would go before the board of supervisors. It started through Traverse county, and the county of Grand Traverse had to shoulder all the bills, as the others were uninhabited. It will be plain at once that the expenses ought to be kept at a minimum. When we came to a range of hills, we did not know which way to go without great inconvenience, but the order of the commissioner came, "Keep your line." We did so, and the state went to the expense of building a road over the hills, grubbing out the forest trees; and an almost impassble road it was, when created. After awhile a lumberman came in. He made a road right around the hills, and in about five miles came into our line, and the consequence was, he had a splendid road, laid on a grade that could take the immense loads that the lumbermen haul.

A few months ago I was called to lay a highway. I went south over an easy grade, and came within 133 feet of a quarter post. The petition was to go to that quarter post, and then turn east on the quarter line. The commissioner was very careful to require me to go to that quarter post. That stood upon a hill as high as this building; it was all a man could do to ever get up or down. But he wanted me to lay the road up that hill to the quarter post and then turn and go down. I said, "Why not lay it around here?" "Oh, the petition didn't call for that; I couldn't do it." Well, after arguing that question with the help of some men who were residents, he did finally decide to locate it around

the hill. I merely wish to show the folly of locating roads under our present system.

Location having been established, the next thing is distance. Distance has been cutting the first figure; it should not be so. We have been trying to shorten the distance, irrespective of grade or anything else; the proper plan is to transpose. Locate your line without reference to distance. First get a good grade, and then make it as short as possible in that grade. There are the two systems—the gist of the whole matter. We have been neglecting the one and observing the other.

The next thing to do in this state, is to have some one authorized, or some board of commissioners authorized, to re-locate roads that are already located or badly located—have authority to step right into a difficult place and say, "Here, gentlemen, this road is going on a grade around this hill, and you may say what you wish; we are going to take that land and put a road there. We are never going to spend another dollar on that hill."

The next stake would be on construction. We have been transposing; we have been trying to construct roads on bad locations. If we have good location first, we may make allowance for poor construction; but if we have a bad location, no good construction can ever accomplish what we want. I know of hills that they have put hundreds and thousands of dollars upon, and there are the hills yet; and I can stand upon the track and, without an instrument in my hand, mark out where I could locate a road to good advantage. I say every man ought to stand right up and put his shoulder to the wheel and say, "Stop, we have gone far enough!"

Another thing we are faulty in; we are not persistent in construction. We do not make it continuous and constant. We make a little effort during the season of the year when it is most convenient to make a road, and then drop it. I say, adopt a plan which will give a force upon a road similar to the way in which Mr. Sears puts a force of men on his railroad. Have a force of men to keep the road in order, to dig ditches so the water will run off. You know of many places where five minutes' work would save a great mud hole, if the work were only

done at the proper time. We ought to adopt a system which will give us continuous supervision and construction of highways, by a set of men specially employed for that purpose.

Another difficulty is this: We cannot carry our labor in one district over into another. Now, Traverse City, in which I live, is so situated that its highways are generally upon a level plain—a sandy plain needing only a gravel covering, and then we have an excellent road; but we cannot step over into our adjoining towns and spend any money; and if they have a hard place which they are unable to level down or improve, why, we have got to go over it. We cannot do anything to assist them. What I mean is to have it so arranged that appropriations of money can be made on roads, perhaps clear through the county or running out from the railway stations or county seat.

Another thing which we should encourage is the handy curve already mentioned; and in locating roads, to secure easy curves. Did you ever notice how easy it was to keep a road in repair at a corner where an easy curve was turned? Almost every one that I can think of, where an easy curve is made in the road, always has a good track. I want to enforce that idea and apply it in the location and construction of our roads—easy curves instead of abrupt angles.

Another difficulty in road construction is that the engineer is entirely eliminated from the question. We have been going on the plan that we did not want any engineer. We get him simply to give us a sight through a compass and then let him alone. I had no rights on that day when I had the confab with the commissioner; I ought to have kept still and let him locate that road over the hill. I say that we have eliminated the engineer, and I want to rise in my might and say, "Let us come up and take the fort." It is time for the people to rise and demand recognition. We have been absolutely kept out from first to last. The application for the location of a highway—the authority in that is confined exclusively to the highway commissioner. There is not a man in the state of Michigan that can say "no" to the highway commissioner. His location cannot even be altered by the board of supervisors. There is not a man in the township

where he lives that can say anything; there is no check upon him. Isn't it a good principle, when you have a man handling money, to have someone else to keep check upon him? I think so.

One more point I want to raise, and I am through. It has been suggested by one of the regents of the university, or one who has held the office of regent, in my conversation with him on the train coming to this meeting, that it might be a good plan to so arrange our engineering courses in the Agricultural college and the university, that a good many of these things that we require of an engineer could be accomplished through the information of these young men and their able tutors. That is, to put into actual practice the ideas that they are taught there, and let them to some extent, through the years to come, go out here in the state of Michigan and do this work. This gave me a new idea, and possibly it may be of some value to adopt a plan by which in the making of estimates, in the location of grades, setting of stakes, watching construction or carrying forward of large contracts, that these men can give us valuable assistance without extra expense. They would be pursuing their instruction under the guidance and control of their professors.

MR. TEED: We built a road last year; and I thought I would tell you how we built it and what it is worth. But as Brother Steele remarked something about the county surveyor it made me think of something I want to say. I want to tell you about the county surveyor in our county. I was away last week, and when I got home, there was a great rush and hurrah. They wanted to find the county surveyor, and everybody I met told me the supervisors wanted to see the county surveyor. I went up; and the way they shook hands! I got an idea in my head that I was the most important man in the county. They stated their business and we transacted it in a little while. But this idea still clung to me, and I said, "I have been county surveyor for twelve years, and when I serve this term out it will be fourteen. Now," I said, "I never asked for anything yet, and seeing I have to keep the records, and seeing I had to buy the safe to keep the records in, and had to rent an office to put the safe in, that I would ask the county to pay

one-fourth of my office rent." They almost fainted away, but when they got over it, they began to laugh; and when they did, I said, "Gentlemen, it wasn't anything but a joke."

Well, we built last year about eight miles of what we called a boulevard. Of course, as it was built outside of the city, the money was all raised by private subscription. It was built around the shore of the lake. The only soil was this light sand. We surveyed the road just as if for a railroad so far as crooks and curves were concerned, but then the question was how to get the gravel? Now, it has been suggested by one or two persons that in a great many townships there wasn't any gravel, and in a paper read this morning, a means was suggested to get the gravel. Now, the gravel over half of that road was hauled ten miles and it did not cost much. One of the logging roads, extending out of the town ran through an excellent patch of gravel. It had gravel and clay, just the right amount. Now, they took light iron and laid right along this track, and went up into the woods, hauled the gravel down and dumped it. When they got the gravel the whole length of the road, they pulled the track up, and put the gravel in the middle. This is a good gravel road, and there was no gravel to be gotten within a good many miles, and yet it was not very expensive. When we built on the south side of the lake, they adopted the same method, so far as putting it on the cars, but there was a gravel pit right at hand, and they didn't sift the gravel, one part gravel, two parts sand, and they fixed the road on the south side of the lake. But that never has packed and never will pack if left alone; and they will have to fix it just as we re-gravel our roads in town. The way we did that, we got the road-bed prepared all right, and then spread that over with three inches of clay. We then put on four to six inches of of gravel, according to the amount of travel, and if the sand was sifted. Of course, if sifted, it would take less gravel and less clay; first three inches clay and then five or six inches of gravel. That packs down and makes a road as hard as a stone. We found it cheaper to put on the clay than to sift the gravel.

The way we came to do it was this: The people that built the first streets in the town said, "We want to make this road

so that the rest of the people will catch the idea and build their roads right. We drove stakes twenty feet apart, up the line of the street, and four rows of stakes—drove them down to where we wanted the sub-grade, and then put an assistant of mine to work right along with the contractor. He put strips three inches wide and filled the clay up to that. Then he put small stakes down, that would come to the top of the clay, and put on his strips five and six inches wide, and then filled the gravel to that. When finished, we had just the amount of clay and gravel that we needed. This year the question came up of building some more roads, and some of the council objected. They said, "We have a city surveyor; let him stake it out and take his levels," but they didn't think it would pay to put a man on there to work right along with him; but, of course that question was argued, and the system we have is to have this man work right along with the contractor. He sets the stakes in the first place, and has them to work from, and puts just so many inches of clay and gravel.

Now this boulevard—the part that didn't work. We have got to take a scraper and go through, and throw the gravel out to the sides, and then go and put that clay in, and then throw the gravel back, either with the scraper or by hand.

MR. HODGMAN: I want to make a suggestion: We were to leave the question of construction until after we had the papers on that subject, and instead of discussing the question how to make roads, first get at the point of how to improve the laws. I would suggest that we appoint a committee of three to collect the points upon which we seem to be agreed as to the way our laws should be amended, and to collect and codify them.

MR. APPLETON: I would like to know if the gentleman's idea is, to have the committee collect and codify from the whole mass, and submit to this meeting before it adjourns? Won't the time be a little short?

MR. HODGMAN: I don't know as any committee could, during this session, codify these statements. My idea was, to select the points, codify them—those that we seem to be agreed upon, *print them*, and send out to members who are

not here for their suggestions, and then place it before the proper authorities.

MR. CHURCH: I wish to say just a few words that Mr. Steele's remarks suggested: We sometimes succeed in getting the commissioner to locate the right road, and then find in a short time, somebody's land is taken. He works by some hook or crook to get the commissioner to take up that road and put it over some hill, and it is done. A good location and money as well, lost. When the road is well located, it should be out of the commissioner's power to easily move it.

MR. STRONG: As to the change we want made in the law, it seems to be pretty well agreed, and it is the opinion of those who have looked the matter up, so far as the law is concerned, that the probabilities are, that we will not be able to make any radical change in the near future. Isn't it wise then for us to try and make a bridge for ourselves? In this matter of roads, if it is probable that we cannot accomplish what we would like, isn't it wise for us to study more particularly on what we can do at the present time to improve the system we now have, so as to make it answer temporarily the needs and purposes of the public generally and the farmers, and yet flatter their prejudices, and yield to the opinion which probably will be the opinion of the state and of the legislature, so that we can accomplish almost what we want at present, and some day, accomplish all that any of us imagine.

It is possible for us to improve the system we now have, and I have simply given this as a matter of suggestion.

MR. HODGMAN: I want to speak a few words more, regarding the point I presented this forenoon. It was right in line with the argument presented by the last speaker. I believe that we are to be compelled to use our existing agencies to a great extent; I myself have very grave doubts as to the results of putting any constitutional amendment before the people. The people in the state of Michigan have got in the habit of voting down constitutional amendments. I believe, that under the plan I presented, we can have our road laws improved, without changing the constitution. We have tested for years and years, the plan of the mill tax for the support of our public schools; I believe a similar tax for the support of our high-

ways can be made by the legislature. I think without any constitutional amendment we can put an end to the present want of system of work on the highways. I don't know of a man who would not say, that with money to work on a road, he can do four times as much as is done at present. I believe the people of Michigan are willing to abolish the present system of laboring on the highways; our legislature can levy the tax without a constitutional amendment. I think we can make use of our present highway commissioners, and by having a Board, for the purpose of reaching the roads that concern the people of more than one neighborhood, make at least a good beginning without any constitutional amendments. Now, the best thing I know of in the way of an education, is a good piece of road in a neighborhood. I think we can start the matter right now, and my plan, I think, is feasible.

MR. BAILEY: I move that a committee of three be appointed to draft a bill to be presented to the legislature. I think that is the right thing. We might talk for four weeks or four years, as engineers, and the gentlemen sitting up in that big building to-day, if we were to present a bill, would sit right down on it.

Now, I move that a committee of three be appointed to draft a bill to be presented to the legislature, but that bill before it is presented, should be submitted to every member of this organization for his suggestions.

Another thing—I propose that we have two engineers and one granger, and we have a granger right here. He represents a good many thousand of the best farmers in the state of Michigan, and I know it. I would like to see one granger put on this committee, and two good engineers of this Society.

MR. APPLETON: I was talking with Judge Black of this city on my way home from this meeting, and he tells me that so far as the constitutional convention is concerned, that some of us have thought might be held, that it cannot be, and I believe he emphasized it by saying, that there was no question about it at all. The vote in the state must be in proportion to the vote cast for the members of the legislature, which it in no way approximates, and I think his view of the case is entitled to weight; therefore in view of that I think it would be unwise

for us to spend a great deal of time upon a measure that will need an amendment to the constitution. I think it will put it too far off, and so far as the road commissioner is concerned, I am perfectly willing to leave it to the committee.

It has been suggested by some one, that a committee of three is hardly enough, but the difficulty I have always found is, that the committee never all come. I think perhaps five might think of more good than three, if they would work, but if we were to talk here for ten years, you would have to leave it to a committee to suggest to the legislature, and that seems to be the only way to amend the present law. Whatever you do will have to go in the shape of amendments to the present law. I haven't a particle of faith in the ordinary road commissioner. The township of De Witt I think, appropriated the sum of $500 for the benefit of the roads, and they specified two particular pieces of road that should receive the benefit of the $500, in sums of $250 each. Of course, the commissioner went on and expended these sums. The only difference now, and before the commissioner put his $250 on the piece, is that it is infinitely worse now than before, because he drew worse stuff on the road. The people of the township are disgusted, and probably will never appropriate another $500 to be fooled away.

But I think a committee will have to be employed to select the most harmonious suggestions and present them, whether to each member or not—perhaps that is the best way, but I am certainly in favor of the plan, and I think the allusion to Mr. Garfield is good. I think perhaps we might adopt the suggestion made, to have five members of the committee, and thoroughly impress upon them that they should meet with the first named who may be the chairman, and then look this matter over, and get it before the present members of the legislature at as early a day as possible. So far as this road making is concerned, I know some of the best engineers who are the poorest road makers.

MR. STEELE: I think it would be decidedly out of place for the Michigan Engineering Society to go to drafting a bill to present to the legislature; but it would be very much in our line of work to offer a suggestion, either to the proper com-

mittee of the legislature or to the committee on public highways, which would embrace our ideas as practical engineers interested in this subject, in a brief statement of what we believe would be for the interest of all concerned. And I certainly would not reflect upon the ability of the members present, by saying that they are not able to draw such a statement of their views—I believe in going at it, doing it, and having it done. There is no reason why, before we adjourn, if we keep in session part of to-morrow, that we cannot do it.

I make a motion to this effect; that this Society before it adjourns, shall, through a committee, appointed by the chair, consisting of five members, embody its opinion on the subject of road laws, and present it to the highway commission, or to the proper committee of the legislature, as they may deem best.

MR. SELLERS: I support Mr. Steele's motion.

THE PRESIDENT: The question before the Society is, shall we, before we adjourn, appoint a committee of five members through the chair, to draw up an expression of the ideas of this Society with regard to the road laws, and present the same to the legislature?

MR. SELLERS: Are we as a Society, sufficiently well founded in our own minds, to have this committee, in so short a time, suggest anything but what would be susceptible to a great many amendments in the legislature?

MR. HODGMAN: I think we are very nearly unanimous on the important points. I have been greatly surprised that people coming here from different parts of the state, who never had any correspondence with each other on the subject, seem to be so nearly united, and I think great good will come out of our getting together and appointing this committee.

THE PRESIDENT: Are you ready for the question?

The motion seconded and carried.

THE SECRETARY: Mr. Appleton referred to bad work done by a highway commissioner in Dewitt. The other side is shown by the following report, and remarks by T. O. Williams, which came into the Secretary's hands since the Annual was in press and is inserted here in connection with the discussion:

HIGHWAY COMMISSIONER'S REPORT.

ALLEGAN, April 3, 1893.

To the Township Board of the township of Allegan, County of Allegan:

The following is the annual statement of the commissioner of highways, of the township of Allegan, in said county of Allegan, for the year ending April 3, 1893:

The improvements which have been made on the roads, culverts and bridges are as follows:

Expense of building culvert in Rossman's ravine, size 66 feet long, 10x12 feet inside	$1,329.06
Expense of building Kellogg culvert, size 66 feet long, 12x12 feet inside	1,698.92
Repairs on the Maskey culvert	45.80
Repairs on approach to Allegan bridge	68.21
For plank for Littlejohn bridge	55.45
Repairs on Eagle foundry bridge	11.15

South Watson road—three-fourths mile, graded and graveled at a cost of $459.63 over and above about $500 worth of team work donated.

North Watson road—about one hundred rods graded and graveled at a cost of $424.09 over and above $200 worth of team work donated.

Road running north from Greitzinger corners, one-half mile graded, eighty rods graveled at a cost of $477.33 over and above $200 worth of team work donated.

Road running east from Wetmore's one-half mile, graded and nearly graveled at a cost of $149.68 over and above $200 worth of team work donated.

Monterey road—sixteen hundred feet of road graded and six hundred feet graveled at a cost of $542.79

Dumont road—one hundred and forty rods graveled and other repairs made at a cost of $252.15 over and above $300 worth of team work donated.

Cummins road—work done at a cost of	$175.11
State road—work done at a cost of	116.45
Job let	400.00
Cheshire road—job let for	182.50
Saugatuck road—repairs done at a cost of	49.16
Mill Grove road—repairs done	34.44
Kellog hill—repairs done	71.56
Otsego road—repairs done	9.93
Sherwood & Griswold for lumber	72.04
Turner and Renihan—for hardware	29.83
Roscoe Ellis—to apply on job on Wilson hill	50.00
John M. Heath—for plow fixtures	7.64
Thomas Stewart—for plow points	3.45
Snyder & Brown—blacksmithing	1.50
Road scraper blade	8.00
For tile used in the various districts of the township	287.72
Total expenditure	$7,013.62
Amount overdrawn	13.62

More money was necessary to be used than was raised at town meeting, which was $7,000. I would recommend building a culvert on the Dumont road near William Barnes, as the bridge there is in bad condition.

I would further recommend there be $3,000 raised for highway purposes to be used on the roads, where the people will donate sufficient team work to draw the gravel.

CLARK COLLINS,
Highway Commissioner.

Roads in our town are so well built that the item of repairs is very light. The first permanent road, built about eight years ago, has sustained an immense travel and, with the exception of a few loads of gravel placed in the worn out places and a general surfacing up with the road scraper, there have been no repairs.

The roads are very permanent with 8″ to 12″ of gravel on the subgrade. The per cent of grade is established by the township board. The people are very well satisfied with the returns from the money, and at this last town meeting they raised $3,000 by vote, and the town board have the right to raise more and probably will, so as to make two or three miles of road this summer.

THE PRESIDENT: You are all aware, that some time ago, Governor Winans appointed a committee to investigate the subject of road laws, and they have made a report which must largely govern our deliberations. I am pleased to know that one of the members of that commission is present, and we would be very glad indeed to hear from him, especially with regard to the defects which the committee found to exist in the provisions of our constitution.

MR. KINNANE: I feel assured that anything I might offer would not be of much interest to this Association, along the line of road making. Through the courtesy of the Secretary of this Association, I have come here for the purpose of observation and reception, rather than to offer any exposition along the lines of the general subject. I have, however, some views in regard to the legal obstacles of the question —or the problem, as it now stands.

Together with the other two members of the committee, of which I had the honor to be one, the legal aspect of the matter was considered at several sessions, and the two great requisites seemed to be, that there shall be a somewhat revolutionary system of legislation adopted, and somewhat after the fashion that the board of supervisors took. The several counties are hedged in by constitutional environments, so that it may be said, that the whole system of township commissioner and path-master is hedged in so that it is practically impossible to make much of an inovation upon the present system, *without* a constitutional amendment.

You will recall, undoubtedly, because it is a matter of special interest to ourselves, a case that went up from Saginaw county, where an attempt was made to lay out a system of expenditure on county roads, and it was held that it was an invasion upon the prerogatives and the constitutional power of the highway commissioner, and the legislation was held invalid, and the tax levied in consequence not collected.

There was a commission constituted up in Bay county — what is known as the "Stone Road Commission." They have built, as I understand it, nearly fifty miles of stone roads, and made excellent progress; but their system has only worked because of practically unanimous acquiescence, because it stands upon the same basis that the Saginaw scheme stood.

So I see that the first obstacle which confronted us, was the necessity for a constitutional amendment that would do away with the powers of the present township highway commissioner. In other words, that would give the legislature power to accomplish that. Of course, we did not go beyond a mere general statement, for it is simply a matter of engineering skill to carry out the details of any plan.

Our idea was this, that a system of county roads should be laid out that is to say, the main highways, extending to and from the county seat - that it should be under the control of a board of highway commissioners, to embody five, in our proposed amendment, five commissioners to have general power to lay out and discontinue and do everything else in the way of road making upon the main highways of the county that was necessary; and also we embody the idea of special assessments to some extent.

That is the way the matter stands. If anything is done in the way of a general plan that can be developed for a period of years, upon some enlightened scheme of engineering, it seems to me that it will be absolutely necessary to have a constitutional amendment in order to do it. You cannot get rid of the arbitrary power that is given the present township officers now without it. You must draw the teeth of the highway commissioner's power as they now are, before you can accomplish anything else.

I have felt some encouragement from what I have heard to-

day. Coming with the idea of listening, I believe I have more practical information upon the general subject than I have been able to get in some months of desultory reading; and what I hope for now is this (and I believe I speak the sentiments of the commission), and that is that possibly through the interest of the engineers and the bicycle clubs, and such others as may take a general interest in the subject, that a constitutional amendment may be submitted and may possibly be carried, although that would, on the face of it, look like a bad probability. The hope of the whole matter would lie in its being pushed in special interests. It has already been intimated that the farming community, for whose special interest the whole matter will ultimate, will be just the ones to get the idea in the first place that there is a possibility of extra taxation, and when they have that idea, you cannot dislodge it, and there is no room for another; and if they vote at all, they will vote it down. So there is abundant opportunity and neccessity for missionary work, and an intelligent discussion of the matter from a practical standpoint will possibly facilitate the passage of the amendment. If the amendment is passed, there will be a bill introduced so that legislation may be had at this session; after the constitutional amendment is passed, if it shall be passed, and the amendment that we have submitted or something in the nature of it, will clear the way for such legislation as will facilitate and make possible an enlightened plan of systematic road building that will be somewhat of an innovation on what we have been doing, under the path-master system.

I tender my thanks to the Association for their courtesy.

THE PRESIDENT: Do you know whether this proposed amendment has been introduced into the legislature?

MR. KINNANE: It was submitted with the message of the out-going governor, and the report now is in the hands of the proper committee, and I think nothing has been done. It will be submitted without doubt. The amendment covers quite a little ground, and it seems to us necessary, in order to accomplish needed results.

THE PRESIDENT: It seems to me that one of the most effective things this Society can do, will be to pass a resolution properly drawn up, petitioning the legislature to submit this

amendment, or something, such as their judgment shall dictate. I am confident that these gentlemen have examined into this matter thoroughly and know just what they are talking about; and so long as our constitution is in such a condition that we cannot modify our present system, it is a waste of time for us to talk. I do not believe we can ever get good roads so long as we have the present system. You cannot get men fit to build roads, to serve for $1.50 or $2.00 a day.

MR. ALBERTSON: It would seem that it would be necessary to have gravel beds in order to make very much improvement on the roads, whether under the present system or a modified one. And wouldn't it be well to provide that the township could own gravel beds, with a right-of-way to them, and the right of condemnation? That can be done under the present system.

MR. KINNANE: I presume that can be done.

MR. BAILEY: The words just spoken are good. Two years ago I had occasion to look up the road law, and I will simply say here, we haven't a road law in the state of Michigan. If there is any gentleman present who has been highway commissioner, he has probably taken his level and gone on to some hill and set his grade stakes, and about the time he got his team there, he ran against a stump; nothing more nor less than, as the gentleman says, a farmer who had got an idea it was going to cost him something, and away he goes to the county seat, gets an injunction and a man with a high collar on, and I have to—whoa! This is an actual fact, and it has actually transpired within eight miles of this big city.

As the gentleman says, if we have a road law, it should be a radical one. I tried my best to get that right-of-way. I could not get it of him, and I say to-day that you cannot work the public highway in the state of Michigan without laying yourself liable to charge of trespass, and they will sustain an action against you every time, unless you get the right-of-way in proper shape.

I had occasion to look up this law with as a good lawyer as the state of Michigan affords, and he said that under our present law it seemed impossible to do anything upon the public roads. And if the people vote to revise the constitution, I hope

whoever is appointed will see that a proper road law is put in, so that if I am highway commissioner again, I can level and grade my roads. I have been path-master in my district eleven years, and I never worked on a road without setting grade stakes, and the wheelmen always like to turn into my house and get a drink of water at my well; they want to shake hands, and they say, "Mr. Bailey, who built that road along here?" I have made a trotting course there, a mile long. It was used and is used for a trotting course, and it is the only good piece of road between here and Eaton Rapids, if I did help to build the state road.

If we can get the grangers to move in this respect, they will carry an immense amount of influence towards getting what we want; and if we can get them waked up to this idea, we will get some help, because they are the wealthier part of the farming community. They are the lettered part—men who read and study.

Another thing I wish to speak about: why I spoke of Mr. Garfield. He belongs to the state horticultural society. That is a large factor. This society, or the off-shoot that I belong to, for the last five years has talked nothing but roads, laws for better roads, and the ways and means to make them so. You see, the people are getting waked up about roads, and I hope this thing will be brought to a successful issue. I do not think anything will be done this present term, but I do think when our constitution is revised, and the necessary incorporations made, that we can have good roads.

THE PRESIDENT: Any further remarks on this branch of the question, The Road Laws? If not we will proceed to the papers on Road Construction.

MR. STEELE: In the discussion of this subject, we have been governed by the sole idea that we were going to make a dead sure thing of a new plan in the system of highway construction. Now, from the report of this gentleman, we are led to understand that there is an insurmountable obstacle in the way. It occurs to me that I would like to call upon any gentleman present to give his views, if he has any, or turn it a little the other way, ask if any gentleman present knows why the legislature of Michigan, now in session, hasn't authority to pass

a law to restrict, enlarge or control the present highway commissioners of the state of Michigan?

MR. APPLETON: I know no one better qualified to answer the question than George E. Steele, of Grand Traverse. He has been looking up the law a little.

MR. STEELE: I have read enough to keep out of jail so far. But I am one of the kind that doesn't believe in backing down. When you get started on a right thing, or a thing that is going to be right, push it on. I am sorry to see that Mr. Kinnane has gone; I wanted to ask if the commission had considered that question, whether in the event of failure to pass such an amendment, they had considered this question as an alternative, until the other can be brought about, whether we could not make such a change to great advantage.

MR. HODGMAN: I think he made the statement that we could. I wanted to suggest that what I said this morning was with that directly in view. Very likely we shall have to keep the highway commissioner, whether we want to or not, and I made suggestions for the purpose of controlling the highway commissioner. I believe that the highway commissioner is just as much subject to the acts of legislature as any other member of the township or state. That highway commissioner can be controlled I believe, and my whole scheme had that in view. I believe we can put the whole thing right through our legislature without changing the constitution at all. If we get a real good man for highway commissioner, the chances are the people will continue him in office. My whole scheme is with the idea in view of the constitutional amendment failing, and that we should do the best we can with the means at hand.

MR. RANDALL: I think that every session our legislature has been trying to control this same highway commissioner. I believe it is about all lost. I find a great many things in our present road laws, very good limitations on this highway commissioner, all having no effect whatever. It says among other things that the ditches shall be at least ten feet from the center of the road, and that improvements of the roads shall, as fast as practicable, be made with gravel. It goes on to say a great many other things, and if the commissioner followed the law, pretty good roads would result; but this road business is under

the control of the highway commissioner, and when we start to institute any changes, we fail every time; and when we enact laws and try to control him, he does not take the trouble to read them.

We had some trouble in a township adjoining us, where they were going to build a road to our town. We were very much interested in this road, because we wanted the people to come down and trade with us. I asked the commissioner about his specifications. He said, "I am going to turn-pike that whole business. I am going to have it fourteen feet from the bottom of one ditch to the bottom of the other, and have the ditches two feet deep below the natural land, before it is graded." Well, we got to talking about it. We didn't expect to make any suggestions; we thought, though, if he built such deep ditches as that and then drew up his grade, it would make the road pretty narrow, and we thought it ought not to be less than twenty feet wide.

"Well," he says, "I cannot help that, and I think I know how to do this business." It happened that a few of us fellows got around and said: "Mr. Commissioner, there is the law, and if you don't follow it, we will make you sorry," and we got him to change his specifications. Not because the law was there, but because there were a few determined men. I have no faith in this highway commissioner system. Let us have some good roads; I do not think we can do away with the commissioner, but let us have a county system in addition. The gods themselves cannot take back their gifts; we have put this matter in the hands of the road commissioner, and we cannot take back the gifts we have given him. Let them have their township roads, and have them just as muddy as they can, but let us have some county roads.

MR. F. H. WILLIAMS: I think the subject of this discussion has come down to two points—education and legislation. I believe that under our present system, we can go on and improve our roads, and make good highways. I know it can be done. In our own township, one or two men who were up in the business, and knew what good roads meant, insisted we should have half a mile of good road. That one half mile was built. The next year, the farmers of that community and the

business men, turned into our township meeting and voted $1,000 for the further improvement of that road. It was done. Next year we had a vote of $2,000, and during the last six or eight years, the appropriation has amounted to between $20,000 and $25,000, and now we have twenty miles of good roads. Put a good road beside a bad road, and the difference will be appreciated. If you will try that once, you will see the good results.

How can we control the highway commissioner? Simply in this way. Elect a good man. Second, have him required, before he puts one cent of money upon a road, to have a survey made by a good engineer. After you get the plans and specifications, have the commissioner follow them out, place a penalty that he will suffer if he does not, and I think under that plan, and with that system, we can make what we already have, answer. What cannot be cured must be endured, and I think we have a system which we can adapt to good roads, and get good results.

THE PRESIDENT: If there is nothing further to be said on the subject of road laws, I think we had better proceed to the reading of papers on road construction.

STONE ROADS IN BAY COUNTY.

H. C. THOMPSON.

In 1880, the board of supervisors conceived the idea that the highways should be improved permanently, and set themselves at work to formulate a plan for so doing. A proposition to raise one hundred thousand dollars on the bonds of the county was submitted to a vote of the people, and was carried. Committees were appointed by the board of supervisors to visit localities where permanent roads had been constructed, and work was begun on several of the main thoroughfares.

There being no suitable material in the county for constructing the roads, stone was procured in Ohio, and conveyed by boats to the Saginaw river, where it was placed on docks and drawn by teams to the respective roads.

The Ohio stone, not proving satisfactory—being too soft, a better quality was obtained on the shore of Lake Huron at Bay Port, where it was loaded on cars and conveyed by rail to its destination. Considerable gravel was used in the construction of the roads at different times, and this was procured from gravel beds near Mason. All the material used had to be imported, thus making the cost considerable; but the result of having good roads at all times of the year is shown in there being a uniform price and market for all farm products, and never at any time is there a scarcity of any of the necessaries of life, on account of bad roads.

The soil is a sandy loam, and the surface practically level, raising about three feet to a mile from the level of the bay, which affords sufficient grade to convey surface water through artificial channels. The first object to be sought was drainage, and this was accomplished by constructing suitable drains on both sides of the grade. An excavation twelve feet wide, and about one foot deep was then made on one side of the grade to receive the first layer of stone, which was composed of the larger stones, laid flat with edges close together. This foundation would averange four inches in thickness. Upon this layer was placed stones of smaller size, and in the early part of the work the surface was made smooth by pounding with hammers, until the stones on the surface would be about one and a half inches in diameter. Later, the top dressing was put on entirely with crushed stone. Gravel was also used as a top dressing, but this was so easily displaced that the crushed stone was adopted. There was no roller used in compacting the stone or the sub-grade. On this account a great many of the stones would be displaced by the traffic, and it would require some time before a uniform surface would be made, and this not until the ruts made by the wheels had been filled by raking in the loose material. A road machine or scraper has been used to do this work, with good results. The first few years the practice was, to make the width of stone twelve feet, but later nine feet was adopted, with a margin of two feet of earth on one side and eleven on the opposite, making a road bed twenty-two feet wide.

This has proven to be of sufficient width for all purposes. The surface of the road has a crown of one foot, and the stone work a crown of four inches which soon wears down level, and after about three years use, requires a top dressing of fine broken stone, to fill up uneven places. The depth of material laid loose, was twelve inches, but when compacted would not be more than eight inches. The stone costs delivered on the railroad, about $5.80 per cord, which would lay about three rods in length, The earth work, hauling and laying the stone was let by contract to the lowest bidders, and varied from $1.60 per rod where the material did not have to be hauled more than one-half mile, to $5.50 per rod where the distance was five miles.

The act authorizing the issue of bonds, also provides that a sum not exceeding two mills each year could be spread upon the cities and townships, included in the stone road district, and the money thus raised, about $30,000 annually, could be used in extending and repairing the roads, which has been done each year, until there are at present, about fifty miles in good condition. The supreme court has decided the tax to be unconstitutional, in that a tax could not be levied in city or town to maintain roads in another municipality. This will end the further extension of the roads, and it will be doubtful if the several townships through which the roads extend, will be able to bear even the expense of keeping them in repair, the cities having paid about nine-tenths of the whole amount expended.

The average cost has been about $6.00 per rod, and I think about thirty cents per rod would keep the roads in good condition.

MR. ROGERS: This question of cost, is something the farmers are very anxious to learn about.

MR. BAILEY: My paper has had all the wind taken out of its sails. If anyone would like to know how I would make a good road, I could tell them in about five minutes.

MR. STEELE: That is what we are here for. If you can tell us in five minutes, we would like to hear it.

HOW TO MAKE A GOOD ROAD FROM THE MATERIALS AT HAND.

M. H. BAILEY.

First survey, level and cross-section the road, noting carefully every water course and depression where water is likely to run or stand. Draw a profile of the work, giving exact grade line of road-bed, depth and width of all cuttings and fills, grade, depth, and size of all water courses, culverts and sluices, natural and artificial, that will be necessary to properly drain the road-bed. Cross-section the road every sixty-six feet, setting stakes for outside of cuts and fills.

Get the right-of-way, if you can, for the improvement of the road and water courses, from the land owners. If you cannot get the right-of-way from them, the statute points out the manner of proceedure.

The right-of-way secured, you are ready to commence work. First excavate your ditches and clean out the water courses. Put in the culverts and sluices; make the cuts, fills, culverts and water courses exactly to agree with the profile; call on the engineer to examine the work and see that it is correct. If pronounced O. K. you are now ready to commence work that twenty-three out of twenty-five individuals will call you a —— fool for doing. They don't know that earth is a sponge and must be made very fine in order to pack down hard. Have a good plow that will easily reach a depth of ten inches. Set it so that it will get there; put on team enough to go along easily. Start in the center of the road; start a subsoil plow in the same furrow that will go six inches deeper than the surface plow, so as to thoroughly break up the road-bed sixteen inches deep. Back-furrow in this way until you have a road-bed broken up thirty-four feet wide. Have hands enough to pick out all the stone, depositing them on the side of the road where they can be handily got by wagon or stone boat, to be placed at the foot of the embankment or where they will be out of the way and not likely to get in the track again. Hitch two good teams onto a good forty-tooth

spike harrow and harrow the ground thoroughly, picking out all the stones. Back-furrow the road to the center again with furrows eight inches deep and six inches wide; back-furrow the road-bed thirty-two feet wide; harrow thoroughly and pick out all the stones as before,until it is as fine as a garden bed. Plow it again commencing three feet out from the center and back-furrow thirty feet wide; harrow it again thoroughly. You are now ready to use a good road grader. Set the ditch end of the blade as low as you can and the road end as high as you can. Go over the track twice, the last time only cutting off the knolls and hummocks that were left the first time over. Clean out your ditches with hand shovels. Now set the blade of the scraper with the ditch end an inch lower than level and the road end an inch higher than level, ditch wheel of scraper three feet from center of ditch. This will level the earth very good. Now set the scraper blade level and square across the road, and drive in the center of the road. This will leave a ridge at each end of the blade; set the blade so as to just level the ridge. The center of the road will now be five inches higher than the grade, six feet from the center four inches higher than grade, at ten feet two inches higher than grade, at thirty feet twenty inches below grade or twenty-five inches below the top of the road. This is just right for a good earth road, and in first-class shape to make a foundation for a gravel road. Now roll the road-bed with a light roller, not less than four feet in diameter, and keep on rolling it, weighting the roller until the ground will not crowd under a weight of 10,000 pounds. If the earth is damp enough, this will pack the road-bed hard enough.

For a first-class gravel road put on three inches of screened gravel nine feet wide and roll it down hard. Put on two inches more gravel eight feet wide and roll down hard. Watch for ruts or abrasions of the covering, filling them promptly, and you will have a road that will last for twenty years as an earth road, or fifty years as a gravel road. On washed sand like that at Sand Pier and along the shores of Lake Michigan, I would not waste time fixing road-bed, only to bring it to grade and put in culverts and bridges, but put the gravel in just as it comes from the pit, four inches thick in the center and ten feet wide. Roll it down hard and then put on more gravel four

inches thick in the center and two inches at the side and roll it hard. This will make a road that will carry fifty teams a day for twenty-five years at a cost for repairs of one mill per mile per annum for each team or $18.25 a year.

MR. ALBERTSON: In case the center of the road is good, what is the object in plowing it up, and disturbing it?

MR. STEELE: I want to compliment Mr. Bailey, so far as relates to the road bed foundation, the work being thoroughly done, it prepares for a drainage which no other system can equal, and that is the first thing for us to look after; but there is one difficulty in the way, and that is, he is working upon a class of soil that will make a road bed; often we have to contend with a soil, that after all the preparation, is no good whatever. After the preparation outlined in this paper, it is no better than it was before. I refer to light sandy lands. We have thousands of miles of that kind of land in Michigan, and the more you plow and harrow it, the worse it is. For the lighter lands, my experience has been, that the best thing is to prepare a narrow way by smoothing it off, and then putting heavy materials on. We practice it in the Traverse City country, and with good success.

While I am on my feet, I want to give an example of the success we have had in Traverse City, in a way that we didn't expect. The road was built about seven miles, over this light, sandy land, and before the work was done it was almost impossible to get a load through there, the wheels cut so deep into the sand. They made a contract—three townships went in together, to build a stone road about five feet wide, covered with clay and gravel. The stones were obtained in the immediate vicinity of the bay, and brought on scows, and only required a little transportation. These were laid, and most of the road was constructed in the way I have said; but the fall of the year came and they couldn't get the stone on the scows to build the road, so there was a strip of about half a mile, for which it was impossible to get the stone. So they raised the question of what to do. Finally, they decided to fill it in with gravel and clay, and then gravel again. Now, by simply following the road back into the hills, there were great quanti-

ties of nice gravel to be obtained. So they made this portion of the road, connecting the two that had been built of stone, with a foundation of gravel and clay, and gravel above, and to-day, that portion of the road is best It traveled better, and it was less expense to keep it in repair, and it has really stood the heavy traffic of that country—which is immense, much better than the stone foundation. The difficulty with the stone foundation was, that the big hard-heads that they put in, would gradually appear in the surface of the road and form obstacles, and the wheels would cut into the sand.

Now, that is a demonstration of just the point I wanted to enforce; that we have here, in unexpected places, and accessible, materials out of which to make our roads—good gravel, and perhaps a little clay, although I would put in very little indeed, and if you have a certain class of gravel, which packs well, it is well enough without any clay, and gives better drainage. If we will set ourselves to work in that line, we can have all the roads we want. I do not think we need to bother our heads over the question of MacAdam roads, etc. We have the material -only take the system, and have the authority to engineer and construct it according to well-known principles, and we will have the results.

The bottom fact of all this, is drainage. Now, what have we got there on that road that is such a success? Why, we have absolutely perfect drainage, and a perfect road bed all times of year.

MR. APPLETON: When this city, some fourteen years ago, purchased what is now called the New Cemetery; they bought it because it was a loose sand, but it was so loose, that in funeral processions, a hack with four persons in it would be stalled in the sand. It was a problem for the council to know what to do to make the roads. One member was very strenuous in advocating a plank road—it was impossible to make it anything else. I urged very much that they allow me to make an experiment on a part of the hill where the most trouble had been experienced. They finally gave me a $120 to work on about sixty rods, and with that $120 appropriation, I went up there, and of course, it was cut down to the hubs of the wheels. You couldn't go through with a buggy; of course, the drainage

was perfect. I put about three inches of clay which I procured right there, and upon that I put gravel—just as it came out of the bank close by. I put on about four inches, and insisted upon every empty wagon, when it drew the clay, going back over the bed, and there was just clay enough. After that course of gravel, I put another course of clay, and then upon that clay I put another course of smaller gravel, from which I was particular to cull the large stones, and we put that on with a rake. I put that over that hill, and I took four or five laborers, and made some road tampers, and the wagons went over it, and it was raked over again, and it has never broken through, and there has never been a shovel put to it so far as I know. Its excellence convinced the council, and they started me all over the cemetery, and I followed the same plan—it is all sand—only of course, I didn't take so much pains, only on this particular hill.

Now, in connection with road making. What is good on one forty rods of road, isn't on another. The character of the soil regulates what you can do. If there had been clay bottom, in this instance, it would have required sub-drainage. Now, that cemetery road, you might imagine, takes no travel; it doesn't take the travel that Michigan Avenue does here, but it takes a great deal—a vast amount of light travel—hacks, hearses, visitors, and every once in a while, a twenty-ton monument; and I have seen a twenty-ton monument going up there and the horses were not phased; that bears out Mr. Steele's idea,—use the material at hand.

MR. STEELE: How much did you put on the third coat?

MR. APPLETON: I was right there. There is a sort of gravel that is mixed up with loam—there is very little of it. I didn't use that for the lower courses. There was not more than four inches thick of it—that, I kept to go over the last time, wherever there was a little bit of a depression.

MR. VINCENT: How wide did you make you road?

MR. APPLETON: I can't tell you just how wide it was—I made it just wide enough for two teams to pass, and it has stood, I think, about fourteen years.

MR. VINCENT: How much did you crown it?

MR. APPLETON; Not enough to make it unsightly. It

wanted to be a little nicer than a country road—not more than three inches on twenty-four feet.

MR. VINCENT: Did you make the clay foundation crown also?

MR. APPLETON: No, sir, it has perfect natural drainage. The sole purpose in putting the clay on the bottom, was to keep the sand from coming through.

The first course was about four inches clay, then three inches gravel, and then a top dressing of this finer gravel. I had no roller, but I had some broad wheeled wagons, and as the empty wagons went along, I insisted on the broad tire going over different parts; finished off with a garden rake.

MR. VINCENT: I am very glad to hear this question of clay and gravel discussed. I have seen intelligent men, surveyors, who thought they understood these things, who thought certain kinds of gravel would combine, because they had cement, but another wouldn't, because it did not have that magic property. There is some gravel that will combine, just as it comes out of the bank, but it is the clay that makes it combine. If we are to succeed with gravel, we must have a binding material. If it is not there naturally, we must put it in, as the last speaker suggested. The more intimately the clay is mixed with the gravel, the better.

MR. APPLETON: The clay makes a good dry weather road, but there is nothing worse for winter, and of course, if you mix the clay and gravel skillfully, you get a good road for both summer and winter, and then in spring, when everything is thawed and breaking up, this road never goes down, only just a little, an inch or so, but it immediately dries up.

MR. BAILEY: The question has been asked, why did I want to plow up the middle of the road? This is a question that all road commissioners have stumbled over. You can't make a good road without plowing it up, except such sand as is found up along our western coast. The reason is this: You have all dug holes in the ground, and you never filled up a hole with the dirt you took out; the ground is like a sponge, and if you don't dig it up, it will settle, and the finer you get it, the better it will settle. You may put in all the drainage you want to, you have got a sponge there, and you can't get rid of it.

If you thoroughly plow up that road bed, it will settle down so hard, and roll down so hard, that when you drive a wagon over it, loaded with 3,000 pounds, there won't be a rut over ¼ of an inch. Then you are ready to put on the gravel.

I built a road of this kind twenty-two years ago, and there hasn't been but one days work laid out on that course in twenty-two years. I keep the top soil on top—on sand I would use gravel, picking out every stone as big as a hen's egg. Screen the gravel if possible—and I want, if possible, to have six inches of good gravel.

THE PRESIDENT: The committee for investigating this matter of road laws and memorials: On this committee Messrs. F. Hodgman, H. F. Bean, Wm. Appleton, M. H. Bailey, and G. E. Steele, are appointed.

There is one more paper on the subject of roads, from Mr. Hodgman. Perhaps we had better listen to that to-night, and that will finish up the subject, with the exception of a paper on highway bridges, and that will probably go over until to-morrow.

MR. HODGMAN: This paper was written originally for another purpose—not for engineers in particular, and it will touch on a good many points that have already been pretty thoroughly covered, and some that have not; and I was in hopes that if I presented it here, it might spur some one on to bring out something that has not been already said. So I beg your indulgence, if you hear something that has been heard before.

COUNTRY ROADS AND ROAD MAKING.

F. HODGMAN.

We shall not have good roads until farmers realize how expensive bad roads are. Bad roads cost more than good roads. Many are so used to bad roads that they seem to think such roads are good enough. Some would not have good roads for fear that a dude on a bicycle would use them.

Let us figure on what bad roads cost, keeping well within the truth and putting it in round numbers. We cannot be exact. You can't haul more than two-thirds as big a load, nor travel more than two-thirds as fast on a bad road as you can on a good one. The wear and tear is more. The town I live in has seventy-two miles of roads. They are fairly good for country roads. If they were all as good as the best mile, the average load hauled could easily be half larger than it is. What the difference would be in a year depends on the amount of travel. Nobody knows what that is. Assume that, on an average, six teams per day pass over all the roads in town. That includes everything. In that case the difference would be two teams per day over seventy-two miles of road, because then four teams could do the work that six now do. Call twenty-four miles a day's work. Then six days' work of man and team is wasted each day. Call it 2,000 for the year. At three dollars per day that is $6,000 a year wasted, where the travel equals six teams per day, or $1,000 a year where it equals one team per day over seventy-two miles of roads.

Mr. L. goes seven miles to market. He had 1,000 bushels of wheat to sell, and he wanted the money. He would have sold in March at ninety cents but, as the roads were he could not deliver it. He sold later at eighty-five cents. When he did sell, two loads a day was all he could haul. It made twenty-four loads. He could have just as easily delivered it in sixteen loads over good roads. He lost the expense of eight trips. At $1.50 each that makes $12, which the bad roads taxed him that time.

THE SMALLEST ROAD TAX

we pay is that which is levied in the assessor's roll. The bulk of all this tax is unnecessary. We might as well throw the money into the fire. The highway tax that is assessed to us is enough, if it were all paid in money and properly handled, to make fifty per cent better roads than it does make. We never shall have good country roads until they are made and controlled by men who know how. Road making is a trade. We never shall have road work done economically until it is done under the direction of competent, prudent men and paid for in cash. That involves a change in our road laws. Each township in Michigan has for years had the power to make the change, but how many have done it, or will do it. (See section 1354, Howell's Annotated Statutes.) When the country was new and the farmers in the interior of the state had to haul their wheat to Detroit and sold it there at fifty cents a bushel, money was mighty hard to get. Our road laws were then well adapted to the situation. Things have changed since then. Laws which were good under those circumstances are abominations now. We Americans are a hundred years behind the rest of the enlightened world in the quality and economy of our country roads, and there is small disposition among our farmers to catch up with or to head the procession. Accepting things as they are the best thing to do for the improvement of country roads is educate those who make them.

HOW TO MAKE GOOD ROADS.

Get the best location. That text warrants a long sermon. For main roads between important points use the shortest line which is consistent with the easiest grades, and lightest work in building. Locate the line upon the same principles that a railroad is located. We seldom do it. We locate roads on section or farm lines when it would be cheaper to buy a man's farm outright and get a good location, rather than to locate and build it on the boundary line. We are generous. We climb hills and dig them down year after year, at no end of trouble and expense to the public, just to keep some man's fields square so that his corn rows will come out even. We are going to keep right on doing so.

Having located the line, you want to build a road that shall have a smooth even surface; hard enough so that wheels will not cut ruts in it and soft enough for horses' feet to take a firm hold without slipping when hauling loads. If somewhat elastic it will be pleasanter to use. In some respects asphalt pavement is the ideal road.

Clear the road-bed of trees, brush, stumps and stones, if there are any. Cut down hummocks and fill holes. Subsequent treatment will vary as the soil varies. As soon as things are ripe for it, begin grading. Do it systematically. Adopt a permanent grade and work to it, so that work once done will stay done. Finish as you go. Do not begin grading a foot more road than you can finish while you are at it. This does not apply to the big hills and hollows that must be dug down and filled up to all eternity.

Drain clay soils thoroughly. Water *must* be speedily got rid of if you would have a good road. Read that over till you have it by heart. Do not be afaid to go outside the road. Ask the owner to help you open the watercourse across his land till the water has a free outlet from the road. If necessary call on the drain commissioner. A few dollars spent in this way will sometimes do more good than ten times the amount spent on the road itself. Tile drains are a great help to some roads. Lay them lengthwise of the track on each side of it. They do little good under the track because the surface becomes puddled so the water does not reach them readily. Be sure the tiles are laid to a true grade and have a free outlet. Wherever there is a sag in the tile the sediment will settle. If the sag is as great as the bore of the tile it will sooner or later cause an entire stoppage. Lay the tiles from two to four feet deep, according to circumstances. Clay roads must be turnpiked or raised in the center, to carry off the surface water. Plow a back-furrow down the center of the road and keep plowing in until it has the desired slope. Keep the ground finely harrowed so as to have the soil perfectly homogeneous and uniform. Do not raise it too high in the middle. A rise of one in twenty is enough.

In Chicago they used to raise the center of the streets *eighteen* inches. They now raise them only eight inches and

get better results. When a wagon is on the slope of a turnpike it is tilted to one side. The most of the weight is on the lower wheels, increasing their tendency to cut a rut, which will intercept and hold more or less of the surface water. That softens the ground and the wheels cut deeper. So it goes on from bad to worse until the limit is reached. The steeper the slope the worse it is, defeating the very object it was made for. The strain on the wagon is greatly increased, and by taking the lower wheels and axles at a disadvantage, greatly increases the danger of breakage.

DO NOT USE

a scoop scraper in finishing a road bed. It is a nuisance. It leaves its loads in hard bunches with soft spaces between, some of which will surely develop into mud holes. Flat scrapers with tongues are much better. You can distribute the dirt evenly with them. A road machine is a good tool to finish the surface with, if you know how to use it, or to spoil it, if you don't. When you have the road thoroughly worked, and just where it ought to be, roll it down hard. Farm rollers are not heavy enough to do the best work. Rollers are made on purpose for it, and ought to be used more than they are. Bring the road bed to the grade where it is to stay the first time you plow it, and then be sure that the plow is never put into it again. A man who will plow up a graded and well settled road bed, ought to be prosecuted, and fined to the full extent of the damage he does, including damages done to people's feelings who have to travel over such a road.

If the soil is muck, put an open ditch on each side of the road at least twenty feet from the center, and give it free outlet. If you have good reason to suspect the presence of a sink hole, do not cut the surface at all, as it will do more hurt than good, in case there is one. If the muck is very soft you may have to put in a log crossway for a foundation. Put good solid stringers lengthwise of the road bed. Notch the cross-logs onto the stringers so they will stay firmly in place, and be as even on top as possible. If they are flattened on top, so much the better, they will need but little covering. If not flattened, put on a good layer of brush and marsh hay, and cover it with the best *dirt* you can get. A log crossway becomes in time a

great nuisance, unless the logs are below frost. The frost lifts them, and keeps the road filled with bumping places.

Except in the softest ground, brush makes a better foundation than round logs, and will last until the ground is settled, so it is no longer needed. Use plenty of it. Pack it as closely as possible, and give it a good covering of gravel with a little clay in it if you can get it.

DO NOT TURNPIKE

a sandy road, nor drain it. Wet sand makes a better road than dry sand. I am not speaking of quick sand. Sandy roads are usually pretty level, and need little, if any grading. They should, where it is necessary, be leveled off as evenly as may be. Encourage grass to occupy all the space it can. It pays well to give some sandy roads a heavy coat of manure for the benefit of the grass. Don't turnpike a sandy road. It is a damage to it. Put a coat of six inches or more of stiff clay on a sandy track, and it makes a pretty good road of it, Straw, marsh hay, waste from sorghum mills, and the like, make good temporary applications for sandy roads. They improve the roads greatly while they last, and it pays well to use them in bad places when you cannot do better.

The time soon comes in the life of a road if it is much used, when it will pay to give it a better surface than can be had from sand, muck or clay. Where gravel can be had it is the first thing to use. It makes a surface hard enough for almost any country road, and is a good foundation for a pavement. When you gravel a road, begin at the part nearest the gravel, and put on an even layer about four inches thick, driving over it as the teams come and go. When one such coat is on, wait awhile until it is solidly packed by the passing travel. Then put on more in the same way, until you have enough on. The object in applying it in this way, is to have all the gravel solidly packed from top to bottom. It makes a big difference whether this is done, or whether you have a hard crust on top with loose gravel beneath. If you have a good road roller, you can pack the gravel with that, without waiting for the teams to pack it. The foundation too, should be rolled as hard as possible. Don't use sand instead of gravel. It is a waste of time and money. The gravel should consist of grains

from the size of a kernel of wheat to a hickory nut. Sharp, angular grains are best. If the gravel is to be put on sand, a little stiff, tenacious clay mixed with it, is an improvement. On clay, it will get all the clay it needs from the road bed.

When your road bed is well graveled, let it alone, except to patch up any holes as soon as they show themselves.

DON'T PLOW IT UP.

Nothing better than gravel will be needed for a majority of country roads. When the traffic will warrant paving, it will generally warrant a railroad, which is pretty sure to come. If the road must be paved, call on an expert for advice. It is the best and cheapest way. I will suggest, that brick is now considered to make by great odds, the best pavement that can be had for the money. House brick will not do. They are too soft. Brick are made on purpose and burned very hard and tough. They are nearly as durable as granite, and can be put down for two dollars or less per square yard.

I will close with a very few words on repairing dirt roads. A road machine is the most effective tool I know of for this use. It wants a man to run it who knows his business. Such men are scarcer than the machines are. The machine should be run over the ground in the spring as soon as the ground is well settled, and afterwards during warm weather as often as the roads become rutted. It will smooth down the rough places, fill the ruts, and leave the road in the best possible shape. If not properly used, the road machine is a nuisance. I believe that a great deal more harm than good has been done with them. Too steep slopes are made with them, and big ridges of loose dirt are left in the center, compelling teams to follow the slopes. No ridge of loose dirt should be left. It should be evenly spread over the surface with the machine, and then rolled down hard.

MR. ROGERS: There is one thing that has not been referred to to-day; that is a good road roller drawn by horses or run by steam. If there are any here who have had experience, would like to hear from them.

MR. HODGMAN: I would say that the O. S. Kelly Co. advertise a good road roller in our annual, and if any members have

use for a road roller, I wish they would consult this company. I believe in patronizing the people who patronize us. We hope in our next Annual to give you the advertisements of other firms who make road rollers.

THE PRESIDENT: There is one more paper incidental to this subject relative to highway bridges by Mr. LaRue.

THE PURCHASE OF METAL BRIDGES.

BY BENJ. F. LA RUE.

Where our path is obstructed by an abrupt depression which we cannot travel through, our alternative is to bridge it that we may travel across. Few highways have been made for the purposes of public travel that have not required the construction of some kind of bridges. In recent years the art of bridge building has developed very rapidly, so that to-day we do not hesitate to attempt to bridge whatever obstacle we cannot remove or otherwise overcome. In these attempts we build bridges and we build bridges—some good, some bad, some quite indifferent.

Just at present the subject of good roads is being urged prominently to our notice by the ever increasing requirements of public travel, and we, as engineers, shall scarcely hold our places in the advance guard of human progress if we do not give to this important subject that attention which it is demanding.

Recognizing the positive demand for good roads, the officers of this Society have wisely given that subject a prominent place at this meeting; and as good roads, comprehensively speaking, are impossible without good bridges, the writer was requested to prepare a paper on the ordinary structures of small span, common to nearly all highways, as an auxiliary to the discussion of the general subject. Though of small dimensions individually, these structures are very important because very common, and they are often very poorly designed—if some of them can be said to have been designed at all. For this reason it was desired that the subject should be treated

quite thoroughly and somewhat in detail, but as such treatment of the subject would require considerable labor and the time was rather short, the writer concluded for the present paper to take up a feature of bridge construction which would be treated rather more superficially. The thorough treatment of small structures will make a good paper for a future meeting.

The subject to be now taken up is of no small importance, and it is very pertinent to the general subject. It is the purchase of iron and steel highway bridges.

Of recent years nearly all bridges of importance or of any considerable span are constructed of metal and are purchased from companies who make a specialty of metal bridge construction. A few observations in regard to this purchase may not be untimely; for among those who are informed concerning these transactions it is an open secret that the sales of metal bridges are often conducted upon what could not be designated sound business principles.

The man who offers to sell you a yard of shoddy for a less price than another tradesman offers you a yard of genuine cloth, does not usually offer you a better bargain. The honest tradesman who charges you a somewhat higher price for the reliable article really gives you a much better bargain, though to the inexperienced eye the shoddy may appear as good as the genuine. If you purchase the cloth you make an honest transaction and the tradesman makes a legitimate profit; but if you buy the shoddy you are deceived and cheated. But if the dealer in shoddy charges you a price that is actually higher than is charged by the honest tradesman for the genuine article, representing to you that his shoddy is very superior material, and you are persuaded to purchase those qualities which by strong flights of imagination and the most sublime lying you are led to believe the shoddy possesses, rather than those sterling but ordinary qualities which by the exercise of common sense you know the genuine article to possess, you are duped and swindled. If a dealer simply "sizes you up," ascertains how much money you have and charges you just that much or a few cents less, for the poorest article which by reason of your inexperience he can persuade you to accept, guaranteeing it to be the very best, you must not look upon that dealer as a swin-

dler—rather thank him for the few cents he leaves you. But if all the dealers in some article in your vicinity, learning that you intend to purchase that article, band together, ascertain how much money you have to pay and how poor an article can be imposed upon you, and mark up the price of that article so that the poorest one which you can be persuaded to accept will just take what money you have to pay, or a little more or less for appearances—well, that *is* robbery, indeed. You have not a very high opinion of tradesmen who gauge their prices according to the amount of money they are able to extort from the buyer, wholly regardless of the actual worth, or lack of worth, of the article sold.

But the writer has been digressing; he has been wandering from his subject and writing about dishonesty and swindling when he should have been writing about bridges. He will resume his subject.

When a metal bridge is to be built, one of the first steps in the ordinary method of procedure is to advertise for proposals for its construction, as is usually required by law. This is, in intent, a good law; it admits of abuses, but on the whole it probably works to the interest of the public, for the abuses could be greater did the law not exist.

Proposals are usually advertised for several weeks, but as a rule none will arrive until the last day upon which they are to be received. On that day will usually be received a number of proposals, according to the importance of the structure and the prominence of the advertisement; and each proposal will be personally delivered by the agent of a bridge company. Proposals for the construction of highway bridges are almost invariably received in this manner. The thoughtful man will notice this fact and be inclined to look upon it as having some significance. In seeking a reason for it he may ask some pertinent questions:

Why do all these agents come personally to deposit their bids? Why do they not send them by mail and save traveling expenses? "The United States mail," he says, "can surely be relied upon to transport these proposals safely and cheaply," and he cannot understand why bridge companies think it always necessary to send an agent to bid on a highway bridge when

they can bid on large railroad bridges by mail. He is unable to discern any good reason why this should be true, but is inclined to think there is a reason which is not apparent. He does not say this, for the thoughtful man is prudent.

Ah, well; the thoughtful man will draw his own conclusions and will probably profit thereby, while others not so thoughtful will continue to pay dearly for their lack of discernment. The thoughtful man insists that the principles which apply in the purchase of merchandise apply also to the purchase of iron and steel bridges, and that judgment and common sense should be used in the latter as well as in the former. And in this he is certainly correct.

But it may be well to here state that more than ordinary judgment and common sense is required in the purchase of metal bridges. Special experience and ability is necessary if the purchase be a really intelligent one. Any man with ordinary intelligence can distinguish shoddy from genuine cloth and can usually have a reasonably good idea of the worth of either, but only experts, trained and experienced in both the theoretical and practical features of the matter can discriminate with any certainty between an unsafe bridge and a good one, or regarding what may be a reasonable price. He who buys shoddy gets cheated, but that is all. But the official who purchases an unsafe bridge not only allows himself to be cheated out of money that is not his, and thus violates his trust, but he actually endangers the lives of those who have trusted him.

Bridge failures are not every day occurrences, which is a fortunate fact. But such "accidents" do occur, and though not alway accompanied by a loss of life so as to be noticed by newspapers, yet several such calamities have occurred with the most terrible results. Those at Ashtabula, Ohio, where over eighty persons lost their lives, and at Dixon, Illinois, where sixty people were killed, are still remembered. The former was a railway bridge, the latter a highway bridge. Neither of these were "accidents;" they were frightful disasters for each of which was a definite cause, and for which some person or persons were directly or indirectly responsible. The Tay disaster and the recent Moenchenstein failure might be noticed as prominent calamities, but these were in foreign countries,

where bridges are constructed under a system quite different from that practiced in this country.

It is not necessary to seek instances of these calamities in foreign countries, for the failure of bridges, in one way or another, are estimated to occur at the rate of from thirty to forty per year in the United States.

It is to be noticed, that in each case mentioned, each bridge failed under a load which it was supposed to be perfectly able to carry; and this is almost invariably the case where bridge failures occur, for it is seldom indeed, that a bridge has to carry a greater load than it is believed, or even guaranteed to be able to carry safely.

In one case (Ashtabula), the bridge had actually carried as great, and greater loads, many times a day, for years. From this and similar cases, we are forced to conclude, that the fact, that a bridge that carried a certain load once, or several times, is no proof that it will carry the same load again. And this is a fact well established, and well known to those familiar with the properties of iron and steel, though it is not readily accepted by those not familiar with the action of these metals under stress.

From this statement it will be readily understood, that all so called tests of bridges, by placing loads upon them, in the usual manner, are mere farces, gotten up to deceive purchasers. In order to really and intelligently test a bridge, it is necessary to precisely observe the deflection under load, and compare it with the calculated deflection for the same load, and also note whether the bridge recovers its exact former position when the load is removed. Such tests, based upon the elasticity of the metal, if properly performed, will give a reasonably accurate idea of the proficiency of the structure. It is a well known fact, that any load on a metal structure which strains the material beyond its elastic limit, will, if repeatedly placed upon it, finally cause it to fail; and this load is not necessarily but little more than one-half the load necessary to break it down when placed upon it the first time. The most ordinary bridge should be able to carry its usual load without straining the metal to more than one-half its elastic limit, or about one-

fourth its ultimate strength; if this be the case it can occasionally carry nearly twice this load without injury.

There are to-day, hundreds of highway bridges in the United States, which, were they loaded with a closely packed crowd of people, or with a close column of infantry, marching and keeping step, would fall under the load; and such a fall under such circumstances would be most terrible. There are probably highway bridges in the state of Michigan over which it would be unsafe to pass an ordinary traction engine. And these unsafe bridges are, for the most part, not old, decayed wood bridges, but comparatively new metal bridges.

Some of our iron bridges throughout the country are standing, simply because they have never been loaded anywhere near their guaranteed capacity, which is usually eighty to one hundred pounds per square foot of road way, with a factor of safety of four; i. e., straining the metal to one fourth its ultimate strength. It has been aptly remarked that many of these bridges seem to stand from mere "force of habit and pure cussedness."

Except from the result of one thing alone—the corroding depredations of rust, which may be prevented by thorough painting and a little care—a properly constructed iron or steel bridge should be nearly, if not quite as good after a life of fifty years as the day it was erected. This statement does not correspond well with the fact, that all over the country iron bridges but fifteen or twenty years old are being torn down and replaced by new ones. The statement is never-the-less true. These bridges, however, have not all been bad ones, though many of them have been very inferior, for in some cases the requirements of travel have greatly increased.

But this talk about the "fatigue of metal," when applied to bridges, is nonsensical and delusive,—every word of it. So also is the talk about crystalization. No piece of iron or steel on this earth has ever been known to crystalize, except through the influence of very intense heat. Speaking practically, and with reference to bridges after completion, there is no such thing as crystalization, or the fatigue of metal. These terms have been used where bridges have failed, simply to excuse bad work and evade responsibility.

To put upon any bridge, other than a very old one, sadly in need of renewal, any such warning placard as "All persons are prohibited from driving across this bridge faster than a walk," is a disgrace both to the builders of the bridge and the officials who purchased it. It shows a shameless amount of either ignorance or dishonesty—or both, on the part of the builders and a very liberal lack of common sense on the part of the purchasers.

Every bridge on a public highway should be perfectly safe for any team to cross as fast as may be desired, for the heaviest traction engine to cross, for a drove of cattle to cross on a trot, or a column of soldiers to cross on double quick march; and a bridge that is not safe to carry any and every such load, is not safe for public travel.

In this connection the writer wishes to make another statement. It is, that the average price paid for metal bridges is sufficient for the purchase of bridges that would be in every way first-class, and capable of carrying with perfect safety all loads that are liable to come upon them. To this is added the statement, that the bridges actually purchased are, as a rule, not nearly as reliable as they should be, and often not as strong as represented to be.

And here the question arises, how can officials when purchasing bridges, intelligently discriminate, as to be certain that they are getting safe and reliable structures, and the equivalent of the money which they expend? The men on whom this duty falls are not usually bridge experts, and are not expected to be; and this fact is certainly not to their discredit, for it requires years of special study and experience to thoroughly master the study of bridge construction.

But the difficulty has a remedy. The engineer may be called upon to make the design, or to examine and report on such designs as may be submitted, to inspect the material, details and workmanship, and to advise in all matters appertaining to the structure. With an engineer, if he be expert in bridge construction, there is absolutely no guess work about all this; it is with him simply a matter of mathematics and experience.

And there devolves upon us engineers, to give more

attention to this subject which is certainly of great importance, and which is a branch of engineering to which too little attention is paid. We may not all become experts in bridge designing, and this is not necessary; but we can, and should, so inform ourselves, that we can decide with intelligence and discrimination concerning the design which may be submitted to us, and have reasonably good judgment concerning the fairness of the price. It is not difficult to know about what it is worth per pound to construct a metal bridge, and the price of the lumber used, and then to estimate the weight of the metal and the amount of lumber in the structure. This is the way bridge companies get at it, though there are usually other minor items to be considered.

There is no possible way in which public officials can so judiciously and economically purchase a bridge, and know the exact worth of what they buy, as by employing an expert engineer to advise them regarding all matters appertaining to the structure.

The committee on road legislation presented a report which was discussed, amended and adopted and subsequently presented to the state legislature in the following form:

MEMORIAL.

To the Honorable the Legislature of the State of Michigan:

The Michigan Engineering Society, in convention assembled in the city of Lansing the 19th day of January, A. D. 1893, adopted the following recommendations relative to the highway laws of the state of Michigan, and instructed their secretary to transmit the same to your honorable body, which is hereby done, with the respectful request that the points presented be given due consideration and such weight given them as their merits entitle them to, in any changes that may be made in the highway laws of the state. All of which is most respectfully submitted.

F. HODGMAN,
Secretary of the Michigan Engineering Society.

RECOMMENDATIONS.

1st. We favor the adoption of the amendment to the constitution submitted by the state highway commission, but striking out therefrom all reference to state roads, and we earnestly request your honorable body to present to the people of the

state this or such other amendments to the constitution as may be necessary to give the legislature power to enact effective legislation for the improvement of the common roads of the state. We do not believe there is now or likely to be in the future any necessity for state roads. We would also have the amendment state explicitly that the state aid to be given to counties is for highway purposes.

In the event of the failure of this amendment to carry, we would favor,

1st. Classifying all highways outside of incorporated cities and villages as township roads and county roads.

2d. All township roads to be under the supervision of the township highway commissioner under restrictions to be provided by law.

3d. All township highway expenses to be paid from a uniform township highway fund to be provided by act of the legislature by a levy of not less than $1 or more than $3 for each $1,000 of the assessed valuation of the township. Any amount in excess of that to be submitted to a vote of the electors of the township on recommendation of the highway commissioner, stating specifically the object for which the levy is asked, and giving an estimate of the cost of the proposed improvement.

4th. All expenses for county road to be paid from a county fund to be provided by a similar tax levied upon the property of the county and under similar restrictions.

5th. Extend the powers now exercised by township highway commissioners in acting together, so that all such commissioners in the county may act jointly to determine what roads and bridges in the county are of sufficient importance to the people of the whole county, that they should be constructed and maintained at county expense, and establish the same as county roads and bridges. Provide for a suitable representation of the cities and villages in such cases. Place county roads in their charge, their determinations to be carried into effect by a committee to be elected from their own number. They should assign to each township its portion of roads lying on township lines, and by joint action of committees make partitions of roads lying on county lines.

6th. We would make the township the unit of the road district, and make the township commissioner the overseer. Authorize him to let all road work by contract or to do it by days' work in certain cases where he cannot secure suitable proposals for the work. Provide for constant supervision of the roads and for a check upon the actions of the commissioner.

7th. Require from the commissioner annual itemized reports of all work done and money expended by him during the year, to be made in duplicate to the township and county. Provide blanks for the purpose.

8th. Provide for the purchase or condemnation of the right-of-way for highways, and for the acquiring gravel pits, clay banks and stone and for access thereto.

9th. Require that a plat and a correct description of *all* highways be filed or recorded in the office of register of deeds and in the state land office. Require that permanent monuments be planted at every section corner and quarter post in the United States survey within the limits of the road, at every angle in the road, and at every point where the road crosses a section line, and that the distance be shown to the nearest government corners on each side of such crossing if such corners can be found within half a mile. All this to be shown on the plat. Provide that no money shall be expended from the highway fund upon any highway until such plat is filed. Fix fees for recording highway plats.

10th. Make road laws apply to all platted streets lying outside of incorporated cities and villages.

11th. Fix penalty for moving or destroying monuments planted to define road lines, and provide manner of enforcing it.

12th. Provide that all county roads shall have permanent grades adopted and recorded in some county office with profiles of the same. All heights to be referred to one common base or datum for the county. Where the road lies in more than one county, show the difference, if any, in the datums. Show heights of all railroad crossings and streams, with stage of water when the height was taken.

13th. Provide that all work done in constructing graveled and paved roads be in accordance with detailed specifications, all estimates for earth-work, graveling and masonry to be in cubic yards. If work is done under contract, provide for retaining a percentage of the contract price until the entire work is completed, according to contract. Provide means for a strict enforcement of this rule. Provide that no more work be commenced on roads than can be completed at the time or during the season.

14th. Provide for reports to the county of all work done on county and township roads, of the amount of money expended and from whence derived.

Provide for consolidated reports from every county to the secretary of state, showing amount of mill tax raised, amount

of special tax raised, amount of money expended on roads and bridges, both for supervision and construction, and the length of roads located, paved, graveled, repaired or discontinued.

15th. Provide means of securing right-of-way for drains across private property for road purposes and provide for opening and constructing the same.

16th. Add to the pamphlet of highways laws and blank forms such as are now furnished to highway commissioners, instructions as to the best methods of constructing earth and gravel roads, with plans and specifications of small wooden bridges and of culverts.

17th. Authorize the employment of county prisoners, vagrants and tramps upon work for the benefit of the highways.

18th. It is the sense of this society that from our experience the state as a whole furnishes ample material, of good quality, for the construction of good roads, when applied by men who are qualified to superintend such work and by officers who are chosen with this in view. We believe that we should make the most of what we have—both as to materials and officials. All of which is respectfully submitted by order of the Michigan Engineering Society.

It may be added to the above that it is believed, that even though no amendment to the constitution be made, that the condition of our highways may be greatly improved by an incorporation in statutes of such of the foregoing principles as are not repugnant to our present constitution.

F. HODGMAN,
Secretary Michigan Engineering Society.

Climax, Mich.

At the time of going to press, the secretary is glad to be able to announce that the legislature modified the amendment to the constitution that was submitted by the highway commission, by striking out the part relating to state roads, and making the adoption of the county system optional with the several counties.

The amendment was submitted to the people of the state at the spring election, and carried by a large majority. It is a significant fact that it was carried by the city vote, the majority in its favor in the four leading cities being greater than the majority in the entire state. The rural communities, as usual, voted almost solidly against it.

MR. WILLIAMS: I would state before commencing, that I found when I commenced to do village work, that there were very inadequate means for a beginner to find any monuments or surveys that he could tie to, and to meet that difficulty, I devised something of a system which I have followed. Whether it was good or not, I don't know, and the object of this paper is to bring forth ideas from the members upon some better system than the one I propose.

VILLAGE SURVEYS AND THEIR RECORDS.

F. H. WILLIAMS.

It is an axiom in social and business circles, that lawyers and doctors never agree, and it has been more than delicately hinted that surveyors could well be included in the same category. Be the slur just or unjust, it is certain that surveyors often disagree with the surveys of their predecessors, and that numerous law-suits are the results of such disagreements.

It is a well known fact, that if the person who made the original survey had made a complete record of the same these differences would not arise. Surveyors, as a rule, are more careless in their records than in any other department of their work. Articles without number have been written upon the necessity of records, but that necessity still exists, and will undoubtedly continue. Nine-tenths of the law-suits arising from disputed lines and boundaries would never have been brought, if the records of the original surveys had been properly kept. If such a record is made, so that one surveyor can follow his predecessor, or else the errors be so plain that anyone may detect them, the re-tracing of old lines would be comparatively simple, and litigation would be less. The young surveyor very naturally follows the old surveyor, and while he condemns the methods and work of his predecessor, yet he leaves his work with no other monument to his memory than a series of rotten stakes.

In the surveys and grades of villages, this necessity appears as prominently, if not more so, than in any other

department of a surveyor's work. There is, of course, that foundation of all the records, the village plat. I used to regard that village plat with a great amount of veneration and awe, but active contact with it has destroyed all my veneration. While indispensable as that bit of drafting paper is, it is very similar to a city directory twenty years old. Nothing is located where it purports to be. The stake that was at the north-east corner of lot one, block one, has taken a permanent residence at the south-east corner of some other lot. The monuments and stakes, if there were any, are there no more. An indefinite line with no marked length frequently designates the size of important lots. The difficulties which arise from the village plat, are too well known to every surveyor to need any comment. The location of monuments by the memory of the oldest inhabitant, or last year's wagon track, is, to say the least, a very undesirable, if not exasperating, method.

The question which it is the object of this paper to discuss, is some simple, practical manner by which the records of the grades and surveys of a village may be so kept that the surveyor can ascertain the details of the work of the former surveys, and can follow them when right, and avoid the errors when wrong; that the monuments may be so located that anyone can find them, and that the records when made can be used as evidence in any court of law, where there is litigation on these subjects.

In the first place, the charter of every village and the general law should require that each village should appoint a village surveyor, who shall be required under the authority of the common council to establish grades for all streets, and place monuments at the intersection of all streets; shall be required to keep records of all grades and surveys made by him. No other person should be allowed to work in the village without taking out a license, and agreeing that he will furnish the village surveyor with a record and plat of all work done by him. These records and surveys should be recorded by the village surveyor, who should receive a fee from the village for making the record. All such records should be made prima facia evidence of their correctness, in all cases of controversy in the courts. A very convenient method of keeping these records can be made in the following manner:

First, there should be profiles of each street, showing of course, the rise and fall of ground in the center of the street, and also the grade line. Underneath this profile there should be a plan of the street, on which any alteration of the grade for the sidewalk and gutter can be easily minuted. These profiles are intended principally for working plans, and can be easily preserved by pasting in a large scrap book. A book twenty-four by forty-eight inches can be obtained for ten or twelve dollars.

All the grades of the village should be referred to one datum established by the village authorities, and the grades be established by reference to the heights of the grade at the points where changes are made.

Second, for a record of these grades a book can be made containing at the head of each page reference blanks to the proceedings of the common council where the matter was considered, a reference to the surveyor's record book, and also to the profile book. These pages are lined, and marked into columns. The first column shows the stations, the next column shows the height of the grade at each station where the grades angle, and the third column shows the location of the angels in the grade by streets, or other references.

Third, the more complete record however, can be conveniently kept in a third book, known as "The Surveyor's Record Book." This book is headed in much the same manner as the Grade Record. It has reference blanks to the proceedings of the common council, reference to the profile book, and also the grade record. The left hand page of this book is lined, and is specially adapted to the record of grades. There are three columns, one for the number of the station, one for the height of the ground, and one for the height of the grade. There should be written in this book the height of every station, and also, if deemed necessary, the side heights. The balance of this page is left for the location of monuments, which may be given with witnesses, whereby each stake may be replaced if lost.

The right hand page of this book is left for records of surveys made, which adjoin upon the street named on the left

hand page. By means of this book, after the street is once surveyed, and the record of the work made, any surveyor can follow his predecessor, can make estimates of dirt to be moved or the cost of improvements, can find any monument in a short time, and a complete record of the history of each street, and the improvement made upon it can be preserved. If this book is kept up, both of the others could be done away with, although it is much more convenient to use the whole set.

It may be said with some force, that there is a great amount of labor in keeping such records. It is true, but I do not think it is any more labor than it would be to hunt in the streets for monuments which ought to be there and are not, for grades located by sidewalks which have long ago been torn up, or for lines of surveys which have no more record than a rotten stake or bent gas pipe.

In other words, if the work is well done once, and the record of that work carefully preserved, there is much more value given to the village than there could be through a dozen of surveys of which no trace can be found.

MR. GRANVILLE: Do I understand the gentleman to say that he advocated the system that a village should license a civil engineer or surveyor before he was permitted to practice in that village?

MR. WILLIAMS: No, my idea was that any person practicing, should place the results of his work so that anyone might have the benefit of it.

MR. GRANVILLE: Then the idea is that each surveyor who might go into a village to do a little private work, should gratuitously give the result of his labors to anyone who may come in. It seems to me that a surveyor's private notes are his stock in trade, and that it isn't doing him justice to compel him to give them away without any consideration. It is all right where the work done is public work, and public record should be made; but it seems to me where a surveyor does private work, his notes belong to him alone.

THE PRESIDENT: Did I understand Mr. Williams to say that any man who does any work, should follow this plan?

MR. WILLIAMS: No, only to the extent that when his work is

completed, it should be so placed that anyone can find it. I don't think this would apply to a city.

MR. GRANVILLE: It seems to me that it is the duty of city or village authorities to have their streets properly monumented, if it has not been done before they reach that point of development. They ought to do it if it was not done in the original platting; and if it becomes necessary for a private surveyor to go on and make his surveys, and if he establishes permanent monuments, it is done at the cost of the parties for whom he is doing the work. It might be a good thing for the public to know these facts; but some one ought to pay the surveyor if he is going to open up his private notes.

MR. WILLIAMS: If there is anything which the public ought to know, it ought to be where the public can know it.

MR. GRANVILLE: And the public ought to pay for it.

SWING OF THE COMPASS CARD, EMBARRASSMENT OF SHIPMASTERS, AND FINDING THE MAGNETIC POLE.

H. C. PEARSONS.

There is a swing of the mariner's compass card in azimuth, always deviating vessels to the north of their supposed course, particularly on the great lakes and the Gulf of St. Lawrence and other places where the isogonic curves are close together, that is a perpetual menace to the safety of the vessels traversing those waters, and a mystery to our seamen.

This swing, or motion of the card in azimuth, is not generally known, and consequently is never recognized in shaping the course of vessels, though it is readily shown and the resulting consequences explained when we come to know the place of the magnetic pole.

So far, this point has never been definitely located. Capt. Jas. Ross has indeed found a point in lat. about 70° N., long. 96° W., where the magnetized needle stands vertical; and for a time this was supposed to be the magnetic pole. But later observations showed an immense field to the south and east of this point, over which the intensity of terrestrial magnetism is very much greater than at the vertical pole of Capt. Ross.

Some point, of necessity, in this field, must control the direction of the magnetic meridians in the northern hemisphere. When this point becomes known, all the motions of the card due to terrestrial magnetism, may be explained.

Having been diverted twice during the last season (1892) from my objective point, over the same route on Lake Superior, in vessels whose compasses I had just compensated and swung for quadrantal error, so that we knew the position of the card for all headings of ship, I thought it time to know something of the cause of such results.

I first conceived the idea of constructing a Mercator chart, embracing some 20° of latitude and some 40° of longitude, such

chart to cover the region of the lakes and the Gulf of St. Lawrence. Then from different points on this chart to project the variation recorded from observation for those points, and to observe their common point of intersection, which I deemed would be the magnetic pole.

But I soon found my mistake as to the kind of projection wanted.

The variations for the different geographical positions are referred to the geographical meridians, which converge to the pole, while the meridians of Mercator's projection are parallel, affording no such convergences to a common point.

I then made a conic projection, tangent to the 44th parallel, and finally one to the 47th parallel of latitude, so as to embrace in each the territory above specified.

Then I projected the variation as recorded for different geographical positions by means of lines representing magnetic meridians, expecting these meridians or variation lines to meet at some common point in the magnetic field above mentioned. But, to my surprise, no two pairs of these lines that were neighbor to each other, would meet in the same point. Thus, two neighboring lines projected from points to the south-east of this field, would intersect in a point far to the north-west, while the two lines projected from the south-west would intersect far to the north-east of this field—say a thousand miles or more from the first intersection, and so of all the lines projected—any two neighboring lines projected from one side of this field would intersect in a point far on the other side. Yet I observed that they all crossed each other within a small area, a circle embracing, say, 3° of latitude, and their crossings were very evenly distributed over this area, the center of which I deemed to be the "*magnetic pole*," that governed the direction of the magnetic meridian in the northern hemisphere.

This center I found from both projections to be in latitude 67½° N., longitude 86° W.

And here I may remark that these variation lines or magnetic meridians all appeared to be governed in their intersection by a law analogous to that regulating the plumb line which points, not to the geometrical center of the earth, but

the center of the nearest mass. And we may further suggest that if we assume this magnetic field above referred to, to have a form enlongated in the direction of south-east from the geographic pole, we find the explanation of why the "agonic" line has a "porthand" course, i e., a course that is to the left of the geographic meridian.

Though the graphic method of solving such problems cannot claim to great precision, the fact that both projections give the same results, and the further fact that computations for the motion of the card, based on a knowledge of the relative polar distances, agree almost precisely, as we shall see, with those deduced from observation, for the different geographical positions, show us that for all practical purposes *this determination for the place of the magnetic pole is correct*, though a more elaborate discussion may change it slightly.

Now, comparing the tangents of the two polar distances from any parallel, we have the inverse ratio of the motion of the magnetic needle or the magnetic card to that due to the inclination of the meridians for any difference of longitude. Thus, with this ratio, the inclination or convergency of any two meridians on any parallel of latitude, becomes the measure of the motion of the card between those meridians, subject to limitations to be mentioned.

From consideration of geometry, we know that the inclination of any two meridians on any parallel is found by multiplying the sine of latitude by the difference of longitude intercepted by the two meridians.

To find this ratio, an example will illustrate:

Say it is desired to find this ratio for the polar distance for lat. 43°.

The geographic polar distance $= 90° - 43° = 47°$.

The magnetic polar distance $= 67\frac{1}{2}° - 43° = 24\frac{1}{2}°$.

Thus,

$$\text{Tan. } 47° \div \text{Tan. } 24\frac{1}{4}° = 2{\cdot}35.$$

That is to say,

The motion of the card for any difference of longitude on that latitude, is 2·35 times the inclination of the meridians embracing such difference of longitude. In the same manner, ex-

cept with the use of logarithms, the following ratios are found:

Lat. =	48°	47°	46°	45°	44°	43°	42°	41°	40°
Ratio =	2·54	2·49	2·45	2·41	2·38	2·35	2·33	2·31	2·29

Thus, multiplying any difference of longitude by the factor or ratio for any latitude, and by the sine of such latitude we have the total swing of the card in azimuth, for that latitude and difference of longitude. Or, rejecting unity from the factor, the product will be the change of variation.

A few examples will illustrate:

From Buffalo to Duluth the difference in longitude is 13°, 12′ (See U. S. List of Lights), and the mean latitude is 45°, the sine of which is ·707. Then the total swing of the card is

$$13°{\cdot}2 \times {\cdot}707 \times 2{\cdot}41 = 22°{\cdot}44 \text{ of azimuth,}$$

and the change of variation is

$$13{\cdot}2 \times {\cdot}707 \times 1{\cdot}41 = 13°\ {\cdot}16.$$

From the variation chart of Johnson's Surveying, we have variation by observation

at Buffalo = 4°, 9 to left
at Duluth = 8, 7 to right } 13°, 60.

Now as the change of variation is but the excess of the motion of the card over the inclinations of the meridians, if we diminish the total swing by the change of variation, we will have 22° ·44 −13° ·16 = 9° ·28 = the inclination of the meridians passing through Buffalo and Duluth.

This 9° ·28 is the part of the motion of the card that is diverting vessels on the lakes to the north of their supposed course. And until within some two or three years, no correction was applied for any part of the swing. Now, however, the change of variation is corrected by taking the "mean" variation of the route over which it is desired to sail, into consideration when shaping course, leaving, as before said, that part of the motion of the card due to the difference of longitude, to divert the vessel to the north. For, if we go down the lakes the card turns to the left, diverting the ship to the north; and if we go up the lakes the card swings to the right, diverting the ship to north as before.

Thus before the "mean" variation was applied in shaping

course, the one-half of this total swing of 22° ·44, or say one whole point was effective in diverting vessels to the north between Buffalo and Duluth.

The departure, or distance due east or west made by a vessel traversing the route between these two ports, is 647 statute miles, as measured on the parallel of 45°, which is about their mean latitude. And the departure, to a one point course for that distance is 126 miles.

Then, because the ship sails on a curve instead of a right line, the northing due to the swing of the card will vary as the square of the distance of eastings or westings made.

Thus if the ship make eastings or westings, say sixty miles, she will make northings one and eight hundredth miles, due entirely to the swing of the card. And if she make another sixty miles of eastings or westings on any course without correcting course for change of variation, she will have made four miles of northings from the same cause.

And this increase of the northings, according to the square of the distance sailed, will continue so long as the ship continues to sail without adjustment of course of change for variation—no matter how many, or what course she may sail on.

This is the bear that has worried our shipmasters on the lakes since vessels have been known there. And this same bear is worrying them now on the northern part of our Atlantic coast, and on the Gulf of St. Lawrence, and has been doing so ever since our history began.

As an illustration of the disasters resulting from a want of a knowledge of this motion of the mariner's card, we may refer to the two hundred wrecks, more or less, on *Sable Island* alone.

This island is some thirty-five miles long east and west, by about three miles in width, with a wide area of sand reefs around it, and located in N. Lat. 44° and between Long. 60° and 61° W.

Being in close proximity to the highway of vessels between Cape Race and our Atlantic ports, it has become a source of terror and dismay to shipmasters—particularly of strangers who have to go into the vicinity of it. So fatal has it been to vessels, that it has become known the world over as "*The Ocean Burying Ground.*"

The consideration of a case will show how this motion of a card, which has hitherto been unknown or unheeded, has contributed to the disasters above mentioned. *Example:*

Suppose a ship—a stranger—from the North Atlantic, when off Cape Race, wishes to shape course for New York or Philadelphia.

Knowing the island to be near his course, the master lays his route some thirty to forty miles to the south of the island, lest he may not have bright weather to afford an opportunity for finding latitude, when wanted—and thinking too, that so much of an offing would cover any possible error in shaping course.

The difference of longitude between Sable Island and Cape Race is 7°—near latitude 45°, and distance say, four hundred miles.

Then calling the sine of latitude .7 we have $7° \times .7 \times 2.4 = 11°.76$ = the total swing of the card between those places. And as it is usual at sea to apply only to the variation at ship in shaping course, then half of this swing will be effective in diverting ship to north of the course she may set out on, for we know that the angle between a tangent and a chord, is measured by half the arc intercepted by the chord.

Then going to the traverse table with the half of this angle, or say 5° 50′ as a course, and with four hundred miles as distance, we find 40.06 miles as a departure. Then multiplying the sine of the course, which is say, S. 60° W., we have 35.21 miles as the northing due to the swinging of the card. So the chances are, that our shipmaster would lay our ship away somewhere on the north side of this dreaded "Bone Yard" of the sea.

This same result may be found in another manner. We have seen that for every sixty miles of departure on Lat. 45°, or near that parallel, the northing due to the swing of the card is 1.08 miles, and that it varies as the square of the distance, and that the difference of Long. is 7°, and from nautical tables we find one degree of Longitude on parallell 45°, is forty-nine miles—that is, our westings are

$$7 \times 49 = 343 \text{ miles, and}$$

$$60^2 : 1.08 :: 343^2 : 35.27 \text{ miles northing,}$$

due to swing of card—almost precisely the same result. And we may remark the close agreement of our computed motion of the card, with that given in "*Bowditch's Navigation.*" (latest revised edition.)

The total swing 10°.76, diminished by the inclination of the meridians, is the change, thus

11°.76 − 4°.90 = 6°.80=change of variation.

Change per. observation= 5°.88, as per. Bowditch.

Here we should remark, that we are too far east for the law of the ratios 2.4 to prevail, as we shall presently explain—though as our course lies almost precisely across the isogonic curves, our results by computation may be regarded as quite correct.

And it must be observed too, that the isogonic curves are supposed to cross the parallels at right angles, and this, for all practical purposes may be regarded as so on the lakes, but the case is very different along the northern part of our Atlantic coast, and on the Gulf of St. Lawrence, where they cross the parallel at an angle of about 52°, so that a given amount of longitude does not cross as many of them, as if they crossed the parallels at right angles.

Then multiplying the expression used for the lakes, by the secant of this angle, we will have the change of variation that would be traversed by a given amount of longitude at right angles to them. An example will illustrate.

Say it is desired to compute the change of variation between 75° and 65° of W. Long., for mean Lat. 43° N.—embracing the coast from Delaware to Halifax.

Arranging for logarithmic computation, we have,

Diff. Longitude =	10.	Log.	= 1.0000
Mean Lat. 43° : Sin. =	.682	"	= 1.8338
Ratio Less 1 = 2.35 − 1	1.35	"	= .1303
Secant 52° =	1.624	"	= .2106
Change of variation =	14.°96	"	= 1.1747

From table 50—Bowditch, we find for

Lat. 45° N. Long. 65° W.	Var. =	21°. W.
" 40° N. " 75° W.	" =	6°. W.
Change for variation pr. observation	=	15°

This close agreement of the computed with the observed value of the change of variation, for change of geographical position does not prevail to a great extent from the plane of meridian 86° W., but it speaks, not only for the excellence of the work of observing for variation, but for the correctness of our determination for the place of the "*Magnetic Pole.*"

By going east or west from the plane of this meridian, to a meridian that is at right angles to this plane, or nearly so, we come to a point from which the distance to each of the two poles is the same—or nearly so, for some distance.

At this point, all the ratios that we gave in a table, become unity, and pass to the reciprocal form—attaining their minimum value at the opposite longitude—same latitude. Thus, the ratio of 2.4 for latitude 45, becomes unity at a quadrant distance from us east or west, and $\frac{1}{2.4} = \frac{5}{12}$ in the opposite longitude.

The place at which they become unity, is indicated on the variation chart by the isogonic curves, becoming tangent to the parallels of latitude, or nearly so—so that change of longitude produces little or no change of variation.

These areas of little or no change of variation, for change of longitude are seen at between 30° to 50° W., and between 110° to 150° W. longitude—Latitude 30 N. to northward, where only changes of latitude gives much change of variation.

At our opposite in longitude, the distance to the magnetic pole being greater than with us, the change of variation will result from a deficit of motion of the card, and a vessel would be diverted to the south, instead of the north, as with us.

Having learned how to compute the swinging of the card in advance, for change in geographical position—particularly on the lakes, our Atlantic coast and the Gulf of St. Lawrence—where of all places on the face of the earth shipmasters are in want of help—we are prepared to show, at least, a "*little light.*"

It will be observed that the factors we have used in our computation for the swinging of the card between say, latitude 40° and 50°, vary so little, that for all practical purposes, we may take the mean of each of them for the factor for the whole belt of latitude.

Thus, we may take for the mean ratio, 2.38
which diminished by unity for change of variation, is 1.38
For sine of the mean latitude, take .69
For secant of obliquity of isogonic curves, 52° 1.62
For the divisor 2. take .5

Then collecting these factors into one, and representing the difference of longitude to be traversed in the contemplated run of ship, by D, we have

$$1.38 \times .69 \times 1.62 \times .5\ D = .78\ D = \textit{Correction.}$$

RULE.

That is to say, .78, or for convenience of computation, say 80% of the difference of longitude to be traversed, is a *correction* to be applied to the right, in making eastings, or to the left in making westings, to counteract the swinging of the card.

Applying this rule for the correction of our run from Cape Race to Sable Island—difference of longitude 7°—ship making westings, our correction should be to *left* $.8 \times 7° = 5°.60$

Our correction by full calculation was = 5°.88

On the lakes where the practice of taking the mean variation over the run to be made is in use in shaping course, I have recommended to

Take half the longitude to be traversed as a "*correction*" to be applied, as in the above rule.

I have had the pleasure of seeing the vessels that run me off my course in the early summer, make a first-class course over the longest single run on Lake Superior,—having instructed the masters in the above rule.

Ferrysburg, Mich., Jan. 13, 1893.

Drainage Survey: "Waiting for the Line to be Cleared."

A CASE OF DRAINING THROUGH QUICKSAND.

F. F. ROGERS.

The Crapo farm is intersected by the C. & G. T. railway at a point about twelve miles west of Flint, in T. 6, N. R. 5 E. It was formerly bought by ex-Governor Crapo, is now owned by W. W. Crapo and managed by S. T. Crapo, grandson of the ex-governor.

The farm consists of something over 1,000 acres of land, a large part of which originally was a bad marsh depending on Swartz creek for an outlet. The main drainage is secured by a large open ditch extending from Swartz creek westerly through the center of the farm. This ditch, when my attention was first called to it in the summer of 1890, was not deep enough to give satisfactory drainage to the upper parts of the marsh. I ran a careful line of levels along the ditch, taking reading in the bottom of the ditch and on the bank, finding very little fall—about one foot to the mile. I established a grade line from the bed of Swartz creek with a fall of .04 of a foot to 100 feet. This caused a cleaning out and deepening of the old ditch from six inches to one and one-half feet. This was done, but in so doing a stratum of quicksand was encountered, about one foot above the grade line, near the center of the farm, and where the ditch was from four to six feet deep. However, the work was carried on to completion, and the next year I was asked to examine the ditch again and see how much the bottom varied from the established grade. I found it all right except through this quicksand where it had filled, as a matter of course, one foot or more. Then we decided to put in an eight-inch sewer pipe with well cemented joints through this quicksand and on the established grade, the ends opening in silt basins made of plank.

This sewer pipe was laid one side of the center, leaving the open drain obstructed as little as possible. All of the tile on this part of the ditch were admitted to the sewer with the proper connections.

This has been in successful operation over a year; has not varied at all from the grade line as established, carries all of the flow in dry weather, while the open ditch serves for an overflow in times of high water. Thus the lands above the quicksand were provided with as good drainage at though the quicksand had not existed.

THE PRESIDENT: This paper reminds me of an incident in my early experience, and shows how easy it is sometimes to accomplish what seems to be a very difficult operation. It was the first sewer which I had ever constructed, and I had very little experience in anything but railroad engineering.

I employed two courses of brick and a wooden skew back. These skew backs were eight feet long. The contractor came one day and said he would have to throw up the job; he had gotten into a bed of quicksand and had tried every possible expedient to get through, but with no success. As fast as he would put the brick in they would disappear. I went down to see what the trouble was. I never had had anything to do with any such thing before, but I knew that it wouldn't answer to let him or anyone else know that I didn't know what to do. It happened he had been using some slabs from the saw mill, eight or ten feet long, for holding up the sides of his ditch, and as a last resort, I told him to lay these slabs crosswise, across the ditch, and then go on. He did so, and although that was twenty-one years ago it has not given the slightest trouble since. All that was necessary was to keep the brick out of the quicksand until the mortar had time to set.

MR. SKEELS: I was employed this last summer, in laying the track for the Lansing Driving Club, near this place, on the west side of the grounds. We had to do a good deal of grading, and just as the work was nearly completed, we struck a bed of quicksand—places as large as the table where it was all of a teeter; and they thought they would have to raise the grade of the whole track in order to get rid of it. I suggested to them to lay a tiled drain from that quicksand to a point where they had tiled drain already. This was Saturday. They commenced then, and put tile drain in, and had it in operation early Sunday morning. Monday noon we made an examination of the ground, and it was solid enough so that we went on with the construction of the track.

PUBLIC WATER SUPPLY AND PUBLIC HEALTH.

W. R. COATS, C. AND S. E.

Mr. President and Gentlemen of the Convention:

There is perhaps no question before the American people today, and it involves all the peoples of the entire human race, of such transcendent interest and importance as is the question of *Public Water Supply.*

The well-being, comfort, health and life of the human race, is more closely identified with, and involved in, the *quality* of the water used in our domestic economy, than in any other—perhaps all other causes combined.

I speak here in a general sense relative to *public* water supply; as only in this sense has the engineer very much to do with the subject, *practically*; yet I wish to treat the subject fully and comprehensively, in both its *public* and *private* bearings.

I wish it understood also, that the question of *Public Drainage* is included as a part of my subject.

Public drainage is made more necessary, indeed almost *compulsory*, by the introduction of a public water supply, but public drainage is not posssible without the aid of public water supply, so that the two questions naturally and properly go together, and should be treated under one head.

I believe that more *ill health, sickness* and *death* results from bad water supply and bad drainage, than from all other causes combined.

Disease germs abound in a thousand fold greater proportion in the water we drink, than in the air we breathe, and are far more dangerous taken into the system with the water, than with the air. I very much doubt whether disease germs are *primarily* produced in the atmosphere at all, but these germs are doubtless taken up by the atmosphere from the water, and thus conveyed into the human system in the air we breathe.

In low, marshy districts, where the waters are always loaded with decaying vegetable and animal matter, with all conditions in the highest degree favorable to the production of "*bacterium*," the most minute microscopic disease germs known, the atmosphere is very much of the time dense with fog and moisture. In absorbing this moisture from the *stagnant*, *steeping* waters, doubtless, vast numbers of these minute disease germs are taken up; so that in such localities, both elements, the air and the water unite in their attack upon the health and lives of all who live in such places; hence, the world over, such places are the most unhealthy.

In the temperate zones, where frost arrests fermentation and decay for several months each year, the diseases produced by this agency assume comparatively mild forms; but in the tropics, and especially among the dense population of Hindostan, where this ferment, putefaction, decay and germ developing process is *forever* at work, the result is frightful. Here all the terrible plagues that have afflicted the human race since the dawn of creation, are fomented, and start out on their tours of world-wide devastation. The terrible destructiveness of these periodic plague epidemics is vastly enhanced by the *fears* and *ignorance* of mankind. When a plague starts out on its tour of devastation from its *Asiatic birthplace*, all the people in its pathway become panic stricken with fear, indeed thousands dying from fear alone. It is at once accepted as true, by the mass, that the moment a case of *plague* or *cholera* appears in a place, the entire atmosphere is tainted, and everyone in danger.

I believe the truth to be, that a case of plague or cholera cannot be communicated through the atmosphere, except possibly in wet, filthy localities where the atmosphere is always dense with moisture, and even then perhaps, only when the disease is largely prevalent there.

I think that cool, calm, critical investigation will show that *personal contact* is necessary; that the germs of the disease must be taken into the system before the disease itself can be produced.

Strangely enough, the last place from which this enemy is looked for, is in the direction of its almost invariable

approach, namely, through the medium of our drinking waters.

Water is the *natural developing place*, and *home* of all these disease germs; and water is among the first and most necessary elements of human existence, and yet the average human being is more careless concerning the *quality* of the water he uses than about anything else in his daily life. That which most vitally concerns his well being he, through his ignorance, gives slightest attention to. If we can so educate the people that these things can be *seen* and *understood* in their *true* meaning, then, and not till then, will the question of public water supply receive the attention and treatment its great public importance calls for.

The term *public* water supply is generally understood as applying only to cities, villages, and other large communal aggregations, where a general system is designed to provide for the wants of the entire community; but if we confine ourselves to this view, we leave entirely out of the consideration by far the greater part of all the people.

Except in a very few of our larger cities, by far the greater portion of even our *urban* population obtain their water supplies from *private* sources, almost invariably the ordinary private well, this source being almost *universal* among all *rural* populations. The waters of the ordinary private wells are the most *impure* and *dangerous* waters that we can use; all the more dangerous because of the almost universal *belief* in their purity and excellence.

In this city (*Lansing*), in *Jackson*, in *Kalamazoo*, and indeed in every city in the state except Detroit, more people patronize the *deadly private wells* than patronize the public supply, regardless of the character of the water. Jackson, with 25,000 people, and a public water supply system inaugurated twenty-three years ago, to-day only supplies about 8,000 of her people with water from the public source, leaving 17,000 still wedded to the *poisoned* water of their private wells.

Kalamazoo, with about the same population, and with one of the finest and most excellent water supplies in the world, yet only supplies *two-fifths* of her people from the public source, all the rest taking their supply from the *poisoned* wells.

The chief reason why the people are so slow to discard their

private wells and adopt the public supply, arises from the fact that the almost universal belief seems to be that the ordinary private well furnishes the *purest* and *best* water to be obtained from any source. Another weighty reason may be found in the fact that most of our public water supply developments are so *crude* and *imperfect*, and our water works plants so *inefficient* and *unsatisfactory* in service that the people very largely prefer to keep in the *old channels*.

In proof of the correctness of this view, we may refer to the two cities of Kalamazoo and Ypsilanti. Kalamazoo, with a *perfect* water supply, so far as *quality* goes, and a water works system inaugurated twenty-four years ago, has to-day only 1,800 service connections with her Public water mains, representing only *9,000* of her *22,000* people. Ypsilanti with a water supply of similar quality, and a water works plant inaugurated only *three* years ago, has to-day over *900* service connections, representing *4,500* of her *6,000* people as using the public water. This shows that the *quality* of the public water supply *service* is more important in the public estimation than is the *quality* of the public *water supply*, and that it is well nigh impossible to bring the people into full and general patronage of a public service of such *low grade* as furnished by water works systems of the *Kalamazoo* and *Jackson type;* and four-fifths of all the water works systems of the country are of this inferior type. The only way to change this order of things and place this all important question of public water supply upon a proper footing, will be to educate the public up to a proper knowledge of what a proper public water supply *is* and *means*. Not only must the public be educated up to a true knowledge relative to the *quality* of the waters used and the vital interests involved, but *practical* workers in this field—often only *pretenders*—must be educated up to a higher conception of the "MECHANICS and ENGINEERING" involved.

One of the greatest obstacles we will encounter in this educational crusade, will be the popular faith in the purity of our private well water supplies. To overturn this popular faith will prove an herculean task, all the more so from this wonderful fact: This faith *is primarily well founded*. It is only through the fault of the *mechanics* and *engineering* involved that all the

mischief and danger arises. The *prime* source of the water supply of our private wells *will* furnish the *purest* and *best* water obtainable from *any source*. It is only in the *mode* of development *and utilization* that we are all wrong. *Nature's* process of filteration in the strata of "*Mother Earth*" is far superior to anything that man has yet discovered, or probably ever will discover. In taking our water supply from the *ground*, we must take it from comparatively near the surface, as if we go very deep, we usually find the water so highly impregnated with mineral matter as to be unfit for domestic use. On the other hand, we must *never* take it from *above* the *danger line* of *surface contamination*.

In all cases where the rainfall penetrates the earth and percolates through its strata, these waters in their downward passage become contaminated by largely absorbing the impurities of the atmosphere, and of the vegetable and animal matter encountered, so that we will almost invariably find the *upper levels* of the first subterranean water stratum more or less contaminated with *organic* matter. But right here comes in NATURE'S grand saving clause. It is found that in these *fixed* and *permanent subterranean* water strata, the water never becomes contaminated but to very *slight depth* by organic matter, all this matter being held in suspension *at* or *near* the surface of the water stratum, very much as oil and other lighter matter is held at the surface; so that to obtain *good* water all that is necessary is to go below this thin stratum of *bad* water, and yet not so deep as to encounter the mineral impurities below. In this way every private or public well in the land may be made perfectly safe, if located in a water bearing stratum of adequate thickness or depth.

As now constructed, nearly all these wells only slightly penetrate the water stratum, simply *skimming* their supply from the extreme *surface* of these waters, thus, of course, getting the *cream* of all these *contaminations*. The fact that the organic gases which poison the waters of our private wells, do not affect the *taste*, *looks*. or *smell* of the water, unless present in gross form, renders it all the more difficult to convince the average observer that such water is *dangerous*.

It is the prevalent belief of most people that the water of

their own wells is exceptionally good. As they draw up the "*old oaken bucket*" and drink of its sparkling waters, it is natural to revert, with grateful feelings, to the beautiful sentiment that inspired the production of that old poem. But place a sample of this same sparkling water under the glass of a powerful microscope and what you will see there will speedily banish all romance and sentiment.

Our cess pools and privy vaults and defective drains, are the most dangerous sources of contamination for the water of our private wells. The disease germs in such places are the most dangerous that can be taken into the human system; and if the drainage of these places reaches our drinking water wells, even if in ever so slight a degree, these germs surely will be taken into the system.

The popular belief that twenty-five, fifty or one hundred feet of intervening earth between our cess pools and our wells furnishes ample protection, is entirely fallacious. A little, plain, homely, practical truth will go much further in dispelling this illusion than will whole volumes of theory and metaphor.

This was very clearly illustrated in the experience of the city of YPSILANTI in developing her public water supply and drainage systems. While planning and constructing these works, I tried in every way to impress upon the minds of the people the danger lurking in the waters of their private wells, and the necessity for connecting with the public supply. Very few could be made to believe that the water of their wells was bad, the prevalent belief being that it was exceptionally good. Least of all could they be made to believe that there could be any danger of contamination from their cess pools and privy vaults.

In constructing a trunk line sewer through the finest residence portion of the city, it was found necessary to go several feet deeper than the neighboring private wells with this sewer trench. Within a very few days every well within two blocks (*750* feet) was *drained dry*. After this, it was not difficult for these people to *see* and *believe* that where the water of their wells could so quickly find its way to this sewer trench, through 750 feet of intervening earth, certainly the fluid contents of their cess pools, seldom fifty feet away, could very easily reach their

wells. Had these same private wells been ten feet deeper, and so constructed that water could enter them only through the *bottom*, all danger would have been averted.

I will dismiss the subject of private wells with this observation: If the instructions outlined above are followed, every private well may be made perfectly safe.

To go back to the main subject, *public water supply*, while we find nothing involved very different in principle, yet we find the question far more difficult of treatment. In a private supply, we usually have only the limited requirements of individual cases to provide for; in a public supply, we have the collective whole on our hands.

In almost all localities, we can easily find water enough in the ground to supply a private family of five or ten persons, but when we come to a public supply, involving the needs of five thousand, or five hundred thousand people, it seems a very different thing, and yet it is different only in relative proportion, and it is very rarely that we find the obstacles to success insurmountable.

I have a religious faith, that wherever the ALMIGHTY has ordained that human beings shall find an abiding place, HE has provided within easy reach, every requisite for their comfort, and chief among these requisites, is *good water*.

But very often we *disobey* all God's *sanitary* laws, and thus bring endless suffering and misery, where *obedience* would have brought peace, comfort and happiness.

Many of our cities are to-day poisoning their people, through the agency of corrupt public water supplies, developed in partical or total disregard of all natural *law* and *principle*; many other cities with water supplies ample in *quantity*, and excellent in *quality*, often wantonly poison these excellent water supplies with notoriously bad water, upon every little fancied emergency, and thus keep the health and lives of their people in constant danger.

The city of *Jackson*, with a most excellent public water supply of three million gallons of water per day, while her consumption is only half this amount, yet turns the waters of a foul disease, germ-laden stream into the water mains and service pipes of her public water system, perhaps fifty or one

hundred times a year, or as often as they happen to have a fire.

The only necessity for this terrible and inexcusable practice is entirely due to the *low grade* of *mechanics* and *engineering*, as exhibited in the *development* and *management* of the Jackson water works system.

It is doubtless true that the great majority of our officials on "Boards of Public Works," are honest, and aim to perform their duties faithfully. The chief trouble arises from the people themselves, electing *incompetent* men to serve them in these important places.

A man may be a good shoemaker, a good blacksmith, doctor, lawyer or minister, but the chances are that not one of all these would be in the slightest degree acquainted with the *mechanics* and *engineering* involved in a public water works development. Often some of the least competent of these people are placed in positions of authority upon such boards, and *assuming* to *know*, will perhaps work more mischief in one administration, than a dozen succeeding administrations can undo and rectify. The poor, patient, deluded tax-payers, however, uncomplainingly foot all the bills.

Doubtless, the most striking instance of inefficiency, gross mismanagement, and reckless waste of almost *matchless natural advantages*, is afforded by my own home city, KALAMAZOO, in the management of her public water works system. I should prefer not to use this case in illustration, could the same end be accomplished, and the same good be done otherwise, because everything connected with the Kalamazoo situation is in some degree *personal* to myself; but it is only the *public* good that I desire to promote, and this means the *Kalamazoo public good*, as well as the general public good.

In a case like this, the plain, unvarnished *truth* constitutes what may be termed *heroic* treatment, and such treatment is the only possible way to reach such cases, and accomplish any good.

Kalamazoo has one of the finest public water supplies in the known world, and yet this splendid water supply is so managed, as to be, oftentimes, well nigh worthless.

Twenty-two years ago I developed this water supply, for the then village of Kalamazoo.

This supply is taken from the ground by means of a large well, twenty feet in diameter, and thirty feet in depth, this being the *first* large public water supply ever developed in this manner. Neither the *engineering profession*, or the *public*, had any faith in the feasibility of this enterprise at the time, and it was only after I *guaranteed* the *engineering success*, and *advanced half* of the estimated *cost* from *my own pocket*, that the village authorities permitted me to go forward with the enterprise. The result of this *pioneer* experiment far exceeded my most sanguine expectations. When the work was completed, we had a well that would furnish *three* and *one half million gallons* of *water per day*, and this water was so beautifully *clear* and *transparent* that a nickel could be *plainly seen* on the *bottom* of the well, through a depth of *twenty-seven feet of water*. This marvelous well will to-day, after *twenty-two years constant use*, still furnish three and a half million gallons per day, of the same fine quality of water, and yet the *management* of this splendid water supply is so *bungled* that the city is kept almost constantly on the *danger line of water famine*, and her people in an almost *constant panic* of *fear*. What a comment upon municipal *mismanagement*, in a city with a water supply of *one hundred and seventy-five gallons per capita per day* for her *entire population*, and while supplying only two-fifths, her people is in almost constant fear of a *water famine*, and to meet emergencies, makes provisions to admit the water of a *sewage polluted stream* into her water mains, thereby *poisoning the entire water supply*, and *endangering* the *lives of all her people*.

London, *Liverpool*, and other large European *cities* find that *twenty-seven* to *thirty-five* gallons per capita per day is an ample supply of water for *all purposes*, and this where the *entire population* are consumers. Yet *little Kalamazoo*, with a supply of 175 gallons per capita per day for *all her people*, cannot manage to properly take care of *half of them*. Comment is unnecessary. The whole secret of this miserable situation is simply this: Kalamazoo and all similar water works systems, in their arrangement, simply live from *hand to mouth*, with no possible provision for *emergencies*. While she has at command at *all times* three and one-half millions gallons of water per day, she

cannot at *any time exceed* this rate for a *single half hour*. Yet she has placed herself in a position where she is liable to be called upon for water at *any moment*, at the rate of *seven* or *eight* million gallons per day. As an engineer, I maintain that it is *criminal* to assume such *liabilities* and *obligations* without making *adequate* provision to *meet them*.

To make such provision at Kalamazoo is exceedingly easy; and while such improvement would make everything safe and in the highest degree efficient, in *every branch* of the *public* and *private* service, it would at the same time greatly *reduce* the *cost* to the *tax payer*. At Kalamazoo, with a water supply of three and one-half millions per day, and a pumping capacity of six millions, it is not possible to exceed the three and a half million rate for even a single half hour for any or *all* service. With a small storage reserve, such as the *natural* advantages at Kalamazoo will afford at the *minimum* of cost, water at the rate of *ten* or *twelve million gallons per day* would be *always* at command for any *emergency*, and for as long a time as such emergency is ever likely to last, and this without any *increase in the present supply*. And the *quality* of the water will not be at all *impaired* by this *storage reserve*.

Under such an arrangement *every branch* of the service will be *incomparably superior* to what it is *possible* to make it *now*, and all danger of *water famine* will *forever disappear*.

The city of Ypsilanti, in her public water supply development, furnishes a perfect illustration of the truth of all this, and every feature there has been fully and completely *demonstrated* in *practical use*. Ypsilanti has an excellent public water supply of two million gallons of water per day. She has only one-fourth the population; yet in three years time she has *one hundred per cent more* water takers in proportion to population than has *Kalamazoo* in twenty-four years; and her consumption of water is in excess in the same proportion.

Ypsilanti has a maximum pumping capacity of only two million gallons per day, yet at *any time* and at *all times*, whether her pumps are *running* or *idle*, she has always at *command*, water at the rate of *eight* or *ten million* gallons per day for *any* and *every emergency*, for so long a time as such emergency is ever likely to last.

Every gallon of this water is always under *one hundred pounds pressure* to the square inch, at pump datum, and is thus available at *all times* for the highest and best effect in *every branch* of the *public* and *private* service. These works have reached a self sustaining basis in three years from date of construction. In the Kalamazoo and Jackson systems, the water pressure in the mains never exceeds an average of *thirty pounds* unless specially called for and worked up *after* the *alarm* is sounded. This low pressure is never efficient or satisfactory in *any branch* of the service. In these works, if the pumps stop an instant at any time, or from any cause, the entire service, in every branch, is *instantly dead* until they start again.

In the Ypsilanti type of works, the pumps may *stop entirely* for *six* or *eight* hours in every twenty-four, and yet every branch of the service will go on precisely as if the pumps were running. Indeed, this is precisely what does happen every day at Ypsilanti. At night the pumps are always shut down, and the pumping power is transferred to the electric dynamos, and thus utilized to run the electric street lighting plant. The Ypsilanti type of public water supply as far surpasses the Kalamazoo and Jackson types in *economy* as in efficiency. The Ypsilanti works reach a self sustaining basis in *three years*; Kalamazoo and Jackson, with not better than a *fifth rate* service, are still, at the end of *twenty-three years, thirty thousand dollars behind each year.*

These cases ought to convincingly show how very important and *necessary* it is to adopt *correct principles* in the planning, construction and management of our public works, and more especially as relates to public water supply improvements.

Ypsilanti, at the end of three years, is directly supplying *seventy-five* per cent of her *entire population* with water from her public works, and everyone is entirely satisfied with the service in every branch.

Kalamazoo and Jackson, after *twenty-three years*, are only supplying about *thirty-five per cent* of their population from the public source, and very few of these are satisfied with the service in any branch.

These cases ought to conclusively show the great impor-

tance and necessity of good engineering and good management in this grand field of public work, and that satisfactory results are not otherwise possible.

I have freely used the above named cases in illustration because I am perfectly acquainted with every detail in each of these cases, and because I believe the *public interest demands* this information, and that it is the clear *duty* of the *engineer possessing it* to furnish it.

In the main, all the defective points cited in the Kalamazoo and Jackson cases, will apply to all works of that type, and I feel that it is the duty of the *true engineer* to do his utmost in eradicating these defects.

As before remarked, we cannot do full justice to the question of public water supply, without including the question of public drainage; but I am occupying so much time with water supply that I do not feel justified in devoting much time to the discussion of public drainage, at this time, and will only indulge in a few general remarks on this subject.

I believe it to be of the highest importance, and among our first *duties*, to provide efficient house drainage *everywhere*—in city, in village, and in the country.

Surface or storm drainage, and house drainage, should always be kept separate and distinct. A house drain and a storm drain combined, is a monstrous blunder, and brings endless danger.

The true object, and office of a house drain, should simply consist in the *quick* conveyance of all the filth produced in and about the house safely beyond the *danger limits*.

All house filth is comparatively harmless in its fresh state, and if disposed of before fermentation and putrefacation takes place, nearly all danger is averted; but if we allow this filth to accumulate in cess pools, privy vaults, and other places about our dwellings, we simply leave the door wide open, and *invite* every danger and disease.

If we permit this filth to accumulate, and be stored about our premises, and to be in constant process of fermentation and decay, we are establishing precisely that condition which will most effectually poison the air we breathe, and the water we drink; and at the same time *preserve*, *reproduce* and *perpet-*

uate, the disease germs given off by every case of *sickness* and *death* ever occuring on these premises.

Had this filth been properly disposed of as fast as made, then no *later occupants* of these premises would ever be endangered beyond their *own individual responsibility*.

Both public water supply and public drainage are vital public necessities, but we cannot establish and maintain public drainage without the aid of public water supply. This fact greatly enhances the *primary* importance of public water supply.

I believe this to be true in our situation to-day, that all that is necessary to secure the highest effectiveness and most widely beneficial results in both these grand fields of public work throughout our entire land, is to educate the public up to a true knowledge and understanding of this grand field of work and its requirements.

THE PRESIDENT: This paper discusses a subject which is fast becoming one of the utmost importance in this country, and contains much that is worthy of the serious consideration of the members of this Society. Mr. Coats' theory that the boundary line between good and bad underground water is a very narrow one is not generally understood nor accepted. It is a very important one if correct, and it is to be hoped that at our next meeting Mr. Coats will give us the facts upon which he bases it. The language of this paper may appear to be occasionally severe, but Mr. Coats distinctly disavows any intention of reflecting upon any member of this Society or of the engineering profession. His criticisms are directed solely at the imperfections of the system of water supply which depends solely upon direct pressure without storage.

WATER WORKS AT SOUTH HAVEN, MICH.

GEO. S. PIERSON, ENGINEER.

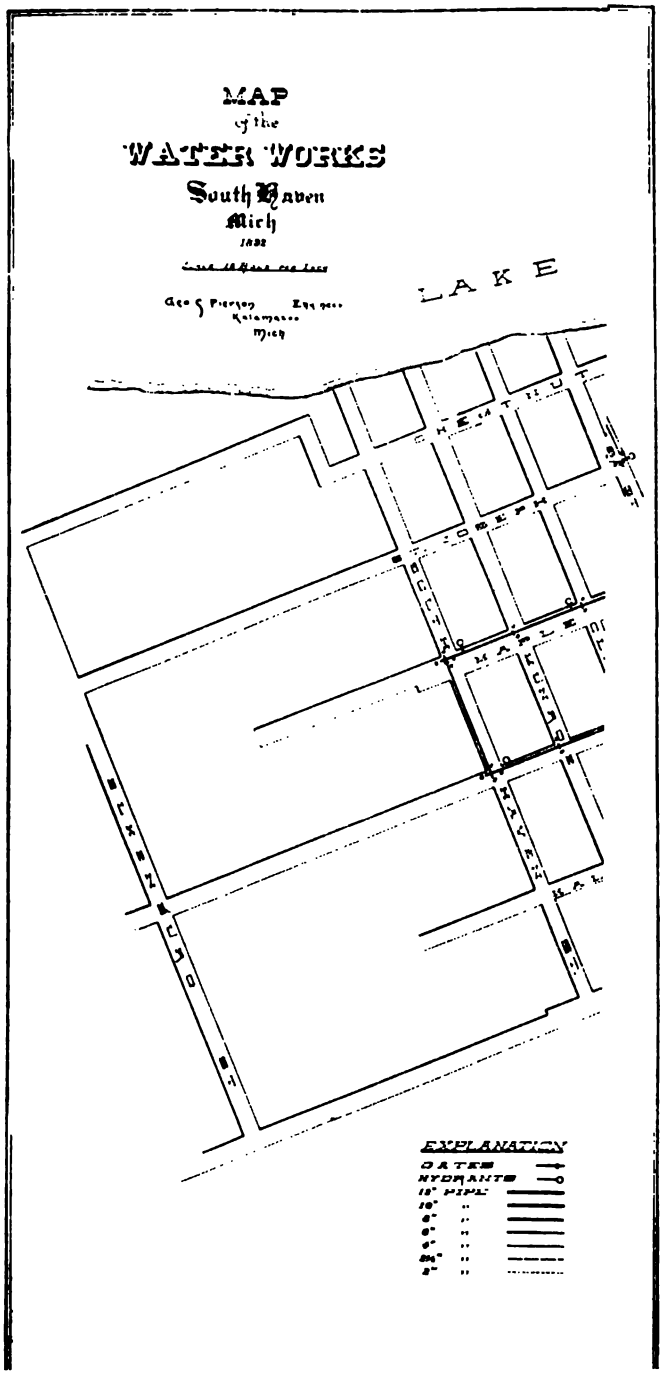
The city of South Haven lies on the shore of Lake Michigan at the mouth of the Black river. It is a place of about 2,500 inhabitants. The larger portion of the city, including most of the business blocks, lies on a plateau south of the river and close by the lake. About one-third of the city occupies a similar plateau north of the river. The portion of these plateaus occupied by buildings lies at an elevation of thirty or forty feet above the level of the lake.

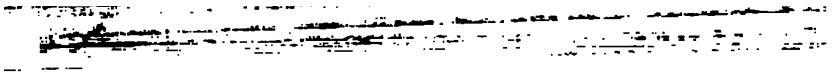
South Haven has within a few years suffered two disastrous fires, and about a year ago voted bonds to the amount of $35,000 for a system of water works. This amount was subsequently increased to $40,000, a portion of which was expended in the equipment of a fire department and the extension of lines of water pipe not originally contemplated.

The water supply is derived from tubular wells on the lake front and is forced into a stand pipe located near the business portion of the city, and standing on ground about thirty-five feet above the level of the lake.

Aside from the method of obtaining a water supply there is nothing about the system particularly interesting to engineers, the details being, in the main, similar to those in other works of this class.

Attempts had previously been made to secure water from the strata bordering the Black river at points above the city, but without success. A suitable supply could be obtained from the lake by a long intake pipe extending out beyond the bars, but the estimates for this intake pipe, protected from the action of storms, which are severe at this point, were about $10,000. This sum, added to the cost of the stand pipe and pumping plant, left very little of the appropriation to be applied to the construction of pipe lines. The problem, then, was to secure at less cost a supply of water sufficient for present needs which could be supplemented in future as the demand arose, at reasonable cost and with certainty.


MAP
of the
WATER WORKS
South Haven
Mich
1888
Geo S Pierson Engineer
Kalamazoo
Mich
LAKE
EXPLANATION
GATES
HYDRANTS
12" PIPE
10" "
8" "
6" "
4" "
3½" "
2" "



An examination of the lake shore revealed the following conditions:

The bed and shore of the lake is sand, rather fine, but well washed and permitting the passage of water with reasonable freedom. The shore rises from the lake at a slope of about three feet in 100 to the foot of the bluff, which is about 400 feet distant. The bluff, with the exception of a surface covering of about three feet of sand, is of tenacious clay as deep as it has been explored. The same clay formation extends under the beach of the lake at a depth of eight or ten feet below the surface of the sand and, continuing, extends under the bed of the lake at about the same depth.

Test wells were sunk at various points in the beach to the level of the stratum of clay, and from their behavior the following conclusions were drawn:

1. There was a slight upward inclination of the water surface from the level of the lake toward the foot of the bluff and consequently a movement of water from the sub-surface underlying the city towards the lake. Chemical analyses of the water from a series of wells arranged at right angles to the lake shore indicated that the water in the upper portion of the beach was polluted, and that the degree of pollution was less as the lake shore was approached.

2. The sand was sufficiently free to admit the passage of water in considerable quantities.

3. Vertical tubular wells of the ordinary form sunk in the shallow layer of sand above the clay must necessarily have short screens placed just above the clay in order to prevent the taking of air by the pumps when the water stratum is lowered by continuous pumping; and since a gang of wells in order to supply a sufficient quantity of water from this stratum must be at considerable intervals, it follows that the relative proportion of connecting pipes to screening surface must be large.

4. The farther from the bluff a supply of water could be secured the purer would the water be.

The following method of obtaining the supply was adopted:

At points thirty feet back from the water line of the lake pits were dug to water. Starting from these pits six-inch tubular wells were pushed out under the lake nearly horizontal, the in-

clination being about one inch per foot downward This is about the inclination of the stratum of clay underlying the bed of the lake. Where the tubular wells pass under the shore of the lake they are about three feet deep, and the depth below the sand gradually increases to five or six feet at the distance of about 125 feet. At about this distance from the shore line screens thirty feet long and as large as can be inserted in the six-inch casing are set. There are three of these wells at present and they are twenty-five feet apart and are connected by pipe lines parallel with the beach into a twelve-inch suction line leading to the pumps.

The history of subterraneous water supplies records many failures. The natural conditions essential to success are

1. A sufficient water shed from which the sub-surface water naturally flows to the point of supply or may be drawn to it by pumping.

2. Porous strata, both at the point of supply and remote from it, through which the sub-surface water may pass to the point of supply in sufficient volume.

The determination of the extent to which these conditions are present is generally a difficult matter. The action of test wells when pumped for a limited time is no guarantee of their performance under continuous pumping, and the fact that one test well supplies a certain quantity of water in a certain time is no guarantee that we can duplicate it by others at invervals of 50 or 100 feet or more which will correspondingly increase the supply even for a limited time; and if they do so for a limited time it may be that all are in a pocket of limited area which will be exhausted so much the sooner.

In the case in point, however, many of the uncertainties surrounding a work of this class are removed. The stratum in which the screens lie is comparatively accessible for examination. There is every reason to believe that it is uniform in character. Lake Michigan, which determines the static head above the screens will, so long as it stands above them, insure a constant supply of water to them, limited only by the capacity of the screens and the five feet of sand above them to convey it. Furthermore, wells placed at no great distance from one another horizontally will not sensibly encroach upon each other,

being supplied along the lines of least resistance or mainly through the sand *above* the screens. The supply can therefore be increased with certainty by additional wells.

If the lake recedes so as to uncover the screens, or the beach extends so as to force the open water beyond them, the wells can readily be extended, or additional ones can be put in to make up for the increased resistance due to the passage of the water through the sand for a greater distance.

The pumps are placed on foundations only seven feet above the level of the lake, in order to make the lift as low, and the action of the pumps as smooth as possible. The three wells readily furnish one million gallons of water per twenty-four hours under a vacuum of ten inches, as indicated by a gauge set on an air chamber thirteen feet above the level of the lake. The air chamber is taken off the suction line at a point seven feet above the level of the lake. Correcting for the lift of the pumps, and the friction in the suction line, the vacuum necessary to induce the passage of one million gallons of water per day through the sand and screens, is about two or three inches of mercury, or, say from 2.25 to 3.4 feet of water.

The water is uniformly clear, even during severe storms. No deposit of fine sand particles can be detected after the water has stood in a deep vessel for some time.

It was anticipated, that possibly the sand about the screens might become so compact by the action of the waves and the ice in winter as to impede the passage of water through it, and a by-pass is provided around the pumps so that the stand pipe pressure may be put upon the screens, and the current through them reversed. Each well is provided with a gate, so that it can be isolated from any, or all the others at will.

In the pump house are two direct acting duplex pumps of the Hughes pattern, each having a capacity of seven hundred and fifty thousand gallons each twenty-four hours.

There are two boilers fifty-four inches by twelve feet, with the usual attachments. Coal oil is used as fuel. It is stored in a special tank near the pump house, from which it is brought to the boilers by a pump. On the supply pipe from the oil tank is a meter. The flame from the burning oil strikes

against a bridge wall of fire bricks at the front of the boiler, which is laid up without mortar, and the bricks spaced about two inches, so that a portion of the flame passes through and against other similar walls. These bridge walls not only distribute the heat along the boiler with less damage to it, but after the fires go down, have a marked influence in keeping up the steam by the heat which they give off. The pumps are run about an hour each day, in the afternoon. Morning and evening, oil is burned under the boilers for about ten or fifteen minutes, and this prevents the steam pressure falling below thirty pounds at any time during the twenty-four hours.

The arrangement of the distribution system is shown on the accompanying map. The main leading from the pump house is ten inches in diameter, and the main connecting the stand pipe with the balance of the distribution is also ten inches in diameter. All hydrants except one are off from lines six inches in diameter or larger, and this one is fed by a four inch line from both directions, which is reinforced at the distance of a block in each direction by a six inch pipe.

Where the water main crosses Black river, it is laid fifteen feet below the surface of the water. It was desirable to test the river crossing before connecting it with the balance of the distribution system, and the following method was adopted.

The pipe was closed at one end above the water by a gate, and into the other end was calked an iron plug. Into this plug a ¾ inch water pipe was tapped, having a water meter and water gauge attached. Water was forced into the river crossing through the ¾ inch pipe, and the meter attached to it by a force pump until the desired pressure was obtained, and then the pump was operated enough to preserve this pressure. By this means could be detected the leakage in a given time at the required pressure.

The following lengths of pipe of the different sizes have been laid.

12	inch,	138	feet.
10	"	2646	"
8	"	3841	"
6	"	18420	"
4	"	4420	"

There have also been laid 2,705 feet of wrought iron pipe for domestic users only.

There are sixty-three hydrants. Some of those in the business portion of the city have independent nozzle cut off.

The stand pipe is fifteen feet in diameter, and one hundred feet high. The lower twenty feet is made of steel ½ inch thick, and at each twenty feet the thickness of steel is reduced 1–16 of an inch, the top course being ¼ inch thick.

The cost of the completed system was about $35,000.00.

MR. WILLIAMS: Do the ends of the tubular wells lie in the [sand?

MR. PIERSON: Yes, under the sand.

MR. WILLIAMS: How did you force them out?

MR. PIERSON: With jack-screws.

MR. WILLIAMS: What sized pipe did you use?

MR. PIERSON: Six-inch.

MR. WILLIAMS: How far below the water is the pipe?

MR. PIERSON: About five or six feet below the bed of the lake.

MR. WILLIAMS: What are these screens attached to?

MR. PIERSON: Pits were first dug, and from them pipes driven out into the lake by jack-screws; after the casing was driven out to that point, the screens were then inserted. Then the casing was drawn back, leaving the screens exposed.

MR. ROGERS: What was the expense of sinking these wells?

MR. PIERSON: The contract price was for $3,000, guaranteeing a supply of three-quarters of a million gallons in twenty-four hours.

MR. ROGERS: How was the river crossing laid below the bed of the river?

MR. PIERSON: The bed was dredged, and the pipe was laid with flexible joints. The pipe was all put together above the water and lowered to its place.

THE PRESIDENT: Did you complete your dredged channel all the way across before you laid the pipe?

MR. PIERSON: Yes, all the way across.

THE PRESIDENT: You did not have much current to contend with?

MR. PIERSON: Very little.

STREET GRADIENTS.

A. L. MARHOFF, BATTLE CREEK.

MR. MARHOFF: [This question has attracted my attention during the last summer more than any other question, from the fact that the city of Battle Creek, of 13,000 inhabitants, until last spring, had no person, who by ordinance or appointment could be called "City Engineer," and of course the streets, as regards grades, were in a very bad condition, only a very few grades having been recorded, and those of about twenty years standing.

I had no idea of edifying the members, in presenting this paper, but do so with the hope of getting information from those that have this work to do.]

Without a doubt there is no one thing entering into municipal engineering that affects the free holder and citizens of any municipality as the fixing of new grades and changing old grades that have become fixed by long usage. It no doubt has occupied the careful consideration of the older members of the profession as well as puzzling the younger members to a greater or less degree.

One of the most perplexing parts of the problem to the engineer is the part relating to intersections, including the elevations of block corners. While the part affecting the lot owner is the amount of cut or fill at the place of his abutting property, which from the nature of the case must receive the careful consideration of the city engineer. Where a city is located in a comparatively level section the problem is very much simplified.

There are three main objects to be attained: First to remove the surface water as soon as possible, second to reduce the percentage of grade to the least possible minimum without material injury to adjacent property, and third to make a street present a good appearance.

To accomplish the first, one should not have a minimum

grade of less than 3-10 of one per cent only in very extreme cases unless the street is paved with brick or asphaltum.

The second case should be governed very largely by the location and nature of the improvements that have been made along the line of the street. On a steep hill side where no improvements have been made to any great extent, or no improvement of any kind, a large cut will be admissible; but if the buildings and other improvements are of a permanent nature before the grade is established, as is too frequently the situation, one is almost, if not quite, compelled to accept the circumstances and make the best of the surroundings. It is therefore of great importance to all concerned to have a grade established and recorded as soon as possible after a street is laid out; then all improvements can be made to conform to said established grade.

The last and by far not the least is to have such a grade established as will give the street a good appearance. This part of the problem is governed largely as to whether the street is in the business or resident portion of the city. In either event the curb line should if possible be unbroken from CURB CORNER to CURB CORNER, but if impossible the grade should change at some property line, and if the change is very abrupt there should be adopted what might be called an easement grade, to prevent as much as possible a large deposit of sand and other easily moved material. By this means the trouble of continually removing the deposit after large showers could be greatly averted. This easement grade is of as much assistance in lessening the expense of caring for a street as are easement curves in railroad work in caring for the track and rolling stock.

And finally we have the street intersection problem, which has almost as many ways of solution as there are engineers engaged in municipal work. I find a very common way of disposing of it is to make all curb corners the same elevation. This has its advantages as well as its disadvantages. The only thing that seems to commend it is that it is an easy way of solving the problem, while it has the disadvantage of failing in being satisfactory on account of lack of drainage, unless what might be termed a compromise grade is adopted, which makes the finished work look as if the whole thing was done

by guess. A flat intersection also presents an ugly appearance, especially on a steep grade. Imagine yourself ascending a six per cent grade and when part way up, meeting with thirty or forty feet of level grade. It will invariably have the appearance of a descending grade. The best solution for resident portions of the city seems to be if the grade is three per

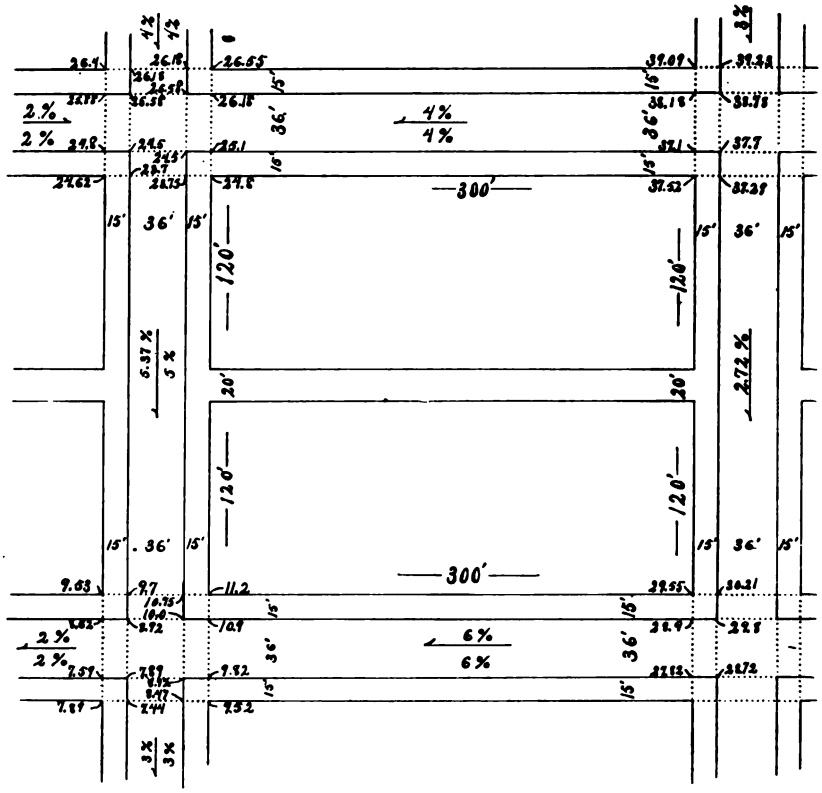


FIG. A.

cent or less, to carry the grade to the center of the intersecting street and make the change, if any, at that point, otherwise change the grade at the curb corner and making the maximum grade for the intersection three per cent. In the business portion of the city the maximum grade for intersection should for various reasons be less than three per cent. The elevation of block corners should in all cases be found by tak-

ing one-half of the sum of the two elevations of the curbs opposite the block corner, plus twice the elevation desired for a block line above the curb, which should be estimated at a 2½ per cent grade. For example: The elevations of the curbs opposite a given block corner are 10.75′ and 10.9′ respectively, and the curb line is fifteen feet from the block line, at 2½ per cent grade; this would make .375′, twice which is .75′. The sum of 10.75′ + 10.9′ + .75′ = 22.4′, which divided by 2 gives 11.2′, then 11.2′ would be the elevation of such a block corner.

The accompanying map (*Fig. A.*) shows a good way of recording such grades as well as better illustrating the plan.

MR. TEED: In his paper, Mr. Marhoff names over the requisites for street grades, and puts the appearance of the thing last. Now, I have been making street grades for about twelve years, and I find that after twelve years lapse of time those streets give the most satisfaction to the public as well as to myself, so far as I have any means of ascertaining, where we make the third requisite the first. I always aim, first to make the street look well, then figure the cost, and then the convenience of the people on the street—that I would put last, and of course if they don't object I don't take that into account at all, and if they do object, they have got to put it before the council, and before they get the matter through the council, their objection keeps growing smaller, and after the street is graded, and the people have the buildings raised up to the street, they forget the trouble and bother, and those streets that have been laid out with the first requisite—the general appearance of the street, are the streets that give the best satisfaction to-day.

I am thinking of residence streets of course, and that being the case, I would make no break at all with cross streets, and if cross streets come in, twist the ends so as to make the sidewalks fit. Fix it up to make it look as well as possible.

MR. SELLERS: What is your minimum grade?

MR. MARHOFF: Three-tenths of one per cent. What is the custom with reference to carrying the intersecting street back where you meet quite an inclination?

MR. SELLERS: The least minimum that I have been able to use is 5-10 of one per cent.

THE PRESIDENT: I don't suppose there is any established custom among engineers—each one has his own way. My practice was, to take the important streets, get as nice a grade as possible, and fit the cross street in as well as possible. I never could follow the same rule with regard to any two streets.

MR. GRANVILLE: Sometimes in carrying a grade up one street, especially where the grade is heavy, you finish your street and it has a nice appearance; but when you attempt to finish a cross street, which perhaps is just as important, you cannot make it present the same finished appearance. Another thing—I think the flat or level intersections are all right. They are good breathing places, and it gives you a better chance to finish most streets. It may be necessary to leave the block corners on the upper side of the hill higher than on the lower; but unless the grades are very heavy, it seems that nearly all intersections can be made about level.

THE PRESIDENT: I was speaking only with reference to streets having very heavy grades. The trouble is in first laying out our cities—instead of going straight up a bluff, the road should slant.

MR. SELLERS: What, as a usual thing, is your rule with regard to the width of a roadway?

MR. MARHOFF: From top to top of gutter, we make it thirty feet.

MR. ROGERS: Another question comes up right here: I think that cities lay out a good many streets at a needless width. A width that the traffic of the street will not demand for years, and thereby materially increases the cost of the pavement and cost of repairs, when a narrower street would answer all purposes.

MR. MARHOFF: That would be very well if you took only cost into consideration, but it is vastly more healthy to have wide streets, and a circulation and pure air, and safer in case of fire.

MR. ROGERS: I believe in having streets as wide as we can get them, but leave a lawn between the sidewalk and the curb.

MR. SELLERS: The question was with me, are they ever

made narrower than thirty feet, and if the rule is wider, I want to know it.

MR. GRANVILLE: In Saginaw, the majority are sixty-six feet in width. By ordinance, the earth streets are made with sidewalks fourteen feet—that would give us thirty-eight feet from the top of the ditch, as you term it, on one side, to the top of the ditch on the other side, leaving probably twenty-six to twenty-eight feet for the road bed proper. Of course, when it comes to paving or graveling, the widths are changed.

MR. SKEELS: In Grand Rapids the sidewalks run from twelve to sixteen feet, and fifty foot streets are the rule, with ten foot sidewalks.

DIGEST OF LEGAL DECISIONS.

The following digest of legal decisions of interest to engineers is compiled from the reports published by the West Publishing Company, by permission:

ADVERSE POSSESSION.

1. To entitle a party to claim by adverse possession he must have made an actual entry upon the lands and occupied the same as owner, but such occupancy may be continued by his agents and servants.—Omaha & Florence Land & Trust Co. v. Parker, (Neb.) 51 N. W. 139.

2. In an action for partition of lands descended, a son-in-law of decedent set up title to a part of the lands occupied by him by adverse possession, and that the same never belonged to decedent. *Held*, there being evidence to show that the son-in-law was induced by decedent to move on the land in question under an agreement that his wife should receive the same on division of decedent's estate, that a verdict against the son-in-law should not be disturbed.—Townsend v. Boyd, (Ky.) 18 S. W. 365.

3. The owner of land, through which a public highway was opened, built a fence across the line, but placed a gate at the entrance of the road, and acknowledged that he did not cultivate the land up to the line because there was a public

road there, and for thirteen years there was travel on the highway without objection by such owner. *Held*, that a claim of adverse possession by him was not justified.—Hempstead v. Huffman, (Iowa) 51 N. W. 17.

4. Where land was given under a verbal gift, and the donees entered thereon, and held the land as their own, and adversely to the claims of the donor, for more than fifteen years, the donees acquired a perfect title.—Spradlin v. Spradlin, (Ky.) 18 S. W. 14.

5. In an action by an owner of land abutting on the west side of a street for damages from the occupation of a portion of it, east of the center line, by railroad tracks, defendant proved two deeds in due form, executed and recorded in 1873 and 1875, respectively, and purporting to convey to it the blocks on the east side of the street. Plaintiff produced three affidavits, in which each affiant swore that, in his opinion, the grantors never owned the blocks, and that defendant obtained the deeds fraudulently, for the purpose of acquiring color of title; but no fact was stated or proven in support of their opinions. *Held*, that the deeds gave defendant color of title, and that its adverse possession under them for ten years established its right to maintain its tracks against any person claiming an interest in those blocks.—Sinnot v. Chicago & N. W. Ry. Co., (Wis.) 50 N. W. 1097.

6. Possession under a tax deed is possession under color of title, sufficient to support a plea of adverse possession of lands beyond the statutory period within which an action must be brought to recover the same.—Smith v. Johnson, (Mo. Sup.) 18 S. W. 21.

7. The grantee of land conveyed under a tax-deed immediately entered thereon and enclosed it by a fence, except a gate-way, and claimed title. Shortly afterwards he sold the land. His grantee at once entered, and began to improve the land, and built a house thereon. Afterwards the land was conveyed to defendants, who have ever since resided thereon. Plaintiff contended that the evidence was insufficient to establish adverse possession, in that the gate-way was not closed, and that there was no verbal expression as to how defendants and defendants' grantor claimed to occupy the land. There was no question but that they had occupied the land more than five years. *Held* sufficient to prove all that is required by Code Civil Proc. § 322, providing that the possession of land for five years by one entering under a witten instrument purporting to convey it shall be deemed adverse, and section 323, providing that, for the purpose of constituting an adverse possession, land is deemed to have been possessed where it has been improved.—Kockemann v. Bickel (Cal.) 28 P. 686.

8. One who dedicates land to the public cannot subsequently acquire it by adverse possession.—Archer v. Salinas City, (Cal.) 28 P. 839.

9. Land dedicated to a public use cannot by adverse possession be acquired by individuals, though the title is held by a municipal corporation.—Yolo Co. v. Barney, 21 P. 833, 79 Cal. 375, followed.—Board of Education of City and County of San Francisco v. Martin, (Cal.) 28 P. 799.

10. Where land was reserved by a municipal corporation for public purposes, it cannot be divested thereof by adverse possession.—Yolo Co. v. Barney, 21 P. 833, 79 Cal. 375, and Board v. Martin, (Cal.) 28 P. 799, followed.—City and County of San Francisco v. Bradbury, (Cal.) 28 P. 803.

11. A deed to a tenant in possession from one who has no title to the land is void, and insufficient as a basis for adverse possession. 11 N. Y. S. 108, affirmed.—McRoberts v. Bergman, (N. Y. App.) 30 N. E. 261.

12. The fact that the owner of a lot had it surveyed, built a shanty upon it, and verbally gave the lot to another, and put the donee in possession, does not constitute the color of title in the donee; and, as color of title is necessary in order that adverse possession of a part of land shall draw to it constructive possession of the whole, the donee by actual adverse possession of a part only of the lot, though she claimed to own the whole, would not acquire title to the whole.—Allen v. Mansfield, (Mo. Sup.) 18 S. W. 901.

13. A quitclaim deed is sufficient color of title to support a plea of title by limitation. Parker v. Newberry, (Tex. Sup.) 18 S. W. 815.

14. A woman, finding a small island in Westchester creek, near New York city, unoccupied, entered thereon without claim or color of title, recorded or otherwise, erected buildings thereon, and remained in possession for twenty years. *Held*, that being a mere squatter, she could not obtain title by adverse possession.—In re City of New York, (Supt.) 18 N. Y. S. 82; In re Blizzard, Id.

15. Title to land is acquired by adverse possession for twenty years under a void tax-title.—Harrison v. Spencer, (Mich.) 51 N. W. 642.

16. Where the owner of an estate for life procures the issuance of a tax-deed to himself, and then conveys the land by warranty deed, possession taken thereunder is adverse to that of the remainder-man, since the warranty deed is color of title in fee.—Lewis v. Pleasants, (Ill. Sup.) 30 N. E. 323.

17. A deed from one to whom a tax-deed, regular on its face, has been issued, constitutes color of title, within the meaning of the statute of limitations, where the grantee takes

it in good faith, without knowledge of any defects, even though the tax-deed was not supported by any judgment, and the person to whom it was issued was under legal obligations to pay the taxes for which it was sold.—Lewis v. Pleasants, (Ill. Sup.) 30 N. E. 323.

18. In tresspass to try title to land lying north of what was called the southern fork of a creek, where defendant claims under a deed from plaintiff, the statute of limitations was of no avail to defendant, though it was shown that he had had possession for the requisite period, where the deed under which he claimed conveyed no land north of the southern fork. —Bassett v. Martin, (Tex. Sup.) 18 S. W. 587.

19. A creditor secured by a deed of trust purchased the land at a void sale thereunder, and the trustee made him a deed purporting to convey it in fee, and such purchaser afterwards conveyed the land in fee to another, and he and his alienee held actual possession, claiming the land in their own right, for the period of the statute of limitations. *Held* that the possession gave title, and barred the right of the grantor in the deed of trust to redeem.—Swam v. Thayer, (W. Va.) 14 S. E. 423; Same v. Young, Id. 426.

20. Whether the planting of trees upon a piece of land, and its use by cutting grass and pasturing cattle thereon during each year of the occupancy, constitutes a practically continuous, exclusive and hostile possession, such as will give title by adverse possession without color of title, is a question for the jury.—Sauers v. Giddings, (Mich.) 51 N. W. 265.

21. The word "hostile," when applied to the possession of an occupant of real estate holding adversely, is not to be constructed as showing ill will, or that he is an enemy of the person holding the legal title, but means an occupant who holds, and is in possession as owner, and therefore against all other claimants of the land. Ballard v. Hansen, (Neb.) 51 N. W. 295.

22. In order to obtain title by adverse possession without color of title, it is not necessary that the land shall be actually inclosed.—Sauers v. Giddings, (Mich.) 51 N. W. 265.

23. An actual entry upon, and possession of land though in fact tortious and without color of paper title, if under a claim of right thereto, in opposition to, and inconsistent with that of the true owner, may ripen into title by adverse possession; and continued acts of ownership upon the property, occupying, using and controlling it as owner, is an assertion of a claim of title, and sufficient notice of such claim to the owner.—Village of Glencoe v. Wadsworth, (Minn.) 51 N. W. 377.

24. In ejectment, when it appears that defendent held

possession of land for over twenty years, claiming up to a certain fence which was supposed to be on the dividing line, whereas in fact, the fence encroached several feet on plaintiff's land, defendent acquires title by adverse possession, though he admitted on the trial that he claimed to the fence because he thought it was the true line.—Battner v. Baker, (Mo. Sup.) 18 S. W. 911.

24. To affect the disseisin of the real owner of the land, the entry, under a duly registered deed from one having no title, must be followed by an open, notorious, exclusive possession, continued uninterruptedly during the statute period.—Roberts v. Richards, 24 A. 425, 84 Me. 1.

25. The essential use and occupation of land by one claiming adversely must be of such unequivocal character as will reasonably indicate to the true owner visiting the premises during the statute period that, instead of suggesting the probable invasion of a mere occasional trespasser, they unmistakably show an asserted exclusive appropriation and ownership.—Roberts v. Richards, 24 A. 425, 84 Me. 1.

26. Where plaintiff relies on possession alone, it must be actual, and not constructive; and the fact that he made one crop on the land is insufficient.—Conn v. Franklin, (Tex. Sup.) 19 S. W. 126.

27. Where coterminous owners of land establish a boundary line, and take possession to the line so agreed on, and one of them erects valuable improvements thereon, and holds quiet and peaceable possession thereof, without objection from the other coterminous owner or his grantees, for a period of more than eight years, such line is binding on them, and those holding under them.—Idaho Land Co. v. Parsons, (Idaho) 31 P. 791.

28. No one can obtain a right in a public highway by adverse use.—Wolf v. Town of Sullivan, (Ind. Sup.) 32 N. E. 1017.

29. Act May 18, 1807, provides that the first seven feet of the sidewalk space of a street in the city of Detroit shall be reserved for erecting porches in front of houses, for grass plat, and for other purposes of utility and ornament, according to the inclination of the proprietor. Act Nov. 7, 1815, provides that no erection on this space shall exceed fifty inches in height, and that every person placing a fence on the front line of the ten feet shall also place another fence on the rear line of said ten feet, along the line of his lot, and said ten feet shall not be severed from the street. *Held*, that where an owner built his house so that it stood partly on a strip claimed to be within the limits of the street, and enclosed the whole strip together with his lot, not separating it therefrom by a fence, he

was not acting within the license of such acts; and his possession of the strip was adverse to the city.—Flynn v. City of Detroit, (Mich.) 53 N. W. 815.

30. When there has been an entry upon land under color of title by deed, although the actual settlement and improvements are on only a small portion of the tract, yet, when there is nobody in possession of the rest of the tract the law presumes the entry to be co-extensive with the grant. Ellicott v. Pearl, 10 Pet. 412, followed.—Smith v. Gale, 12 S. Ct. 674.

31. A person who has actual possession of a part of a tract of land described in his deed has constructive possession of the whole.—Porter v. Miller, (Tex. Sup.) 19 S. W. 467.

32. Where there is no paper giving color of title defining the extent of adversary possession, but it is only under claim of title, the possession will be limited to inclosure, clearing, or actual improvement.—Jarret v. Stevens, (W. Va.) 15 S. E. 177.

33. The possession of a portion of a street by a railroad company entering under authority given by its charter is not adverse to the public, where there is no exclusion of the public use.—Village of Wayzata v. Great Northern Ry Co., (Minn.) 52 N. W. 913.

34. To obtain title to land by prescription of thirty years, the intention of possessing as owner as well as the possession of the land must be proven, and it is not enough to show cultivation of the land.—Clemens v. Myer, (La.) 10 So. 797.

35. In ejectment between owners of coterminous subdivisions of a lot of land in a city, plaintiff claimed under a conveyance describing his subdivision as being "about twenty-nine feet" in width. Conveyances of the other subdivisions of the lot by metes and bounds demonstrated the fact that plaintiff's lot was only twenty-seven feet in width. Plaintiff has always supposed and claimed that his lot was twenty-nine feet wide, but had never been in the occupancy of nor claimed any of the two feet beyond the true boundary. *Held* insufficient to support a claim of title to such strip of two feet by adverse possession.—Kunze v. Evans, (Mo. Sup.) 18 S. W. 36.

BOUNDARIES.

1. A fresh water stream, which at low tide flows through a tidal channel, from which the tide wholly ebbs, does not constitute "low water mark" within the meaning of the colony ordinance of 1641–47, providing that the title of owners of land adjoining tidal waters shall extend to "low-water mark," and such a channel is not a boundary to the land of the adjoining proprietors. FIELD, C. J., and KNOWLTON and LATHROP, JJ,

dissenting,—Tappan v. Boston Water Power Co., (Mass) 31 N. E. 703; Brown v. Same, Id.

2. Flats situate in a tidal river at a point in its course above the line of low tide, are to be divided among the adjoining properties, by drawing lines from the terminal of the latter on the banks at the ordinary stage of water to and at right angles with the center line of the river.—Tappan v. Boston Water-Power Co., (Mass.) 31 N. E. 703; Browne v. Same Id.

3. Plaintiff claimed under a deed describing the land conveyed as beginning at the "sea" on A's line, thence south on the said A's line to the highway; thence west on the highway ten rods to the stake; thence north to the "shore" parallel with said A's line; thence east to the first bounds mentioned. It did not appear that the grantor intended to retain the adjoining as distinct from the upland. *Held*, that the deed conveyed to plaintiff, the flats or shore, with the upland.—Snow v. Mt. Desert Island Real Estate Co., 24 A. 429, 84 Me. 14.

4. Where land bounded southerly on the sea shore, and extending one league in width on each side of a river at its mouth, was granted, together with the island of Mount Desert, and "other islands on the forepart of said two front leagues," in ascertaining the location of the "other islands" mentioned, the rule governing "flats" between adjoining owners of land situated on the seashore does not apply.—Roberts v. Richards, 24 A. 425, 84 Me. 1.

5. On a question of boundary between two surveys, (plaintiff's land and survey No. 8,) the evidence as to the location of the calls in the field notes was conflicting. The jury was instructed, that if they found that survey No. 8 was located on the ground a certain distance "west from the west line of F. county school land, as claimed by plaintiff to find for plaintiff." *Held*, that the instruction was error, as it confined the consideration to one connection called for by the field notes, in disregard of evidence of other calls.— King v. Mansfield, (Tex. Sup.) 19 S. W. 858.

6. It is not error in ascertaining the true locality of the back line of a survey fronting, with established corners, on a river, to reverse the calls of the survey, if it is found that thereby the decrepancy in the area of the survey is lessened, and the back line falls along the line of the alleged conflicting survey, which is, moreover of prior date; the recognized rule being, that the beginning corner in the certificate of survey is of no higher dignity than any other corner.—Miles v Sherwood, (Tex. Sup.) 19 S. W. 853.

7. Where, upon a town plat, the only boundary for part of a street on one side of a navigable lake, the street extends

to low-water mark.—Village of Wayzata v. Great Northern Ry. Co. (Minn) 52 N. W. 913.

8. Where there is a decrepancy between the survey of an addition to a town, as shown by the plat, and as the lines were actually run, the purchasers of lots described merely according to their numbers, take title according to the lines actually run, when they can be ascertained.—Root v. Town of Cincinnati, (Iowa,) 54 N. W. 206; Kerr v. Same, Id.

9. Where it is shown that purchasers of lots in an addition to a town, took possession and fenced their lots soon after the survey was made, and that the person who made the plat pointed out the bounds of the lots, it will be presumed that their possession was taken according to the lines of the actual survey.—Root v. Town of Cincinnati, (Iowa,) 54 N. W. 206; Kerr v. Same, Id.

10. The fact that a deed described the property conveyed as commencing at a known monument on the shore of a pond, and running thence "along said pond," does not show an intention to convey only to the shore. 11 N. Y. S. 87, reversed. —Gouverneur v. National Ice Co., (N. Y. App.) 31 N. E. 865.

11. A deed of land bordering on a small non-navigable lake or pond is presumed to convey title to the center of the lake or pond, unless the contrary appears.—Wheeler v. Spinola, 54 N. Y. 377, distinguished. 11 N. Y. S. 87, reversed.—Gouverneur v. National Ice Co., (N. Y. App.) 31 N. E. 865.

12. A deed described the land conveyed as bounded by the "northeasterly side" of W. street, "together with the free and common use, right, liberty and privilege of said * * * W. street." *Held*, where the whole of such street was on the grantor's land, that the grantee took the fee only to the side line of the street, with a right-of-way over the whole street.—Hobson v. City of Philadelphia, (Pa. Sup.) 24 A. 1048.

13. Gen. St. 1889, par. 1836, provides that, whenever landowners shall desire to establish permanently the boundaries of their lots, they shall notify the county surveyor, who shall forthwith notify all parties interested of the time of making the survey. He shall make the survey at such time, and file the evidence taken, and a plat and notes of the survey, in the office of the register of deeds, within ten days after the completion of the survey. *Held* that, where the surveyor made only a partial survey at the time named in the notice, and completed it six weeks later, without notice to a party interested, the survey did not comply with the statute; and in an action in the nature of trespass, the boundary line being at issue, the survey was not conclusive, and the exclusion of evidence as to the location of the line prior to the survey was error.—Schwab v. Stoneback, (Kan.) 31 P. 142.

14. Where the calls in a conveyance of land are for two corners, one at high water mark on the bank of a stream, and the other at the stream, and there is an intermediate line extending from one such corner to the other, the stream is the boundary, and all riparian rights pass, unless a different intention of the parties is shown by either their conduct or the conveyance.—County of St. Clair v. Lovingston, 23 Wall. 46, and Railroad Co. v. Schurmeier, 7 Wall. 272, followed. 47 F. 757, affirmed.—Whitehurst v. McDonald, (C. C. A.) 52 F. 633.

15. Where a street, as abutting on which a lot was conveyed, had been surveyed and its location designated by stakes set at the corners of the lot when the deed was made, the boundary of the street forms the boundary of the lot, though the measurements given in the deed would include a portion of the street, whether the grantee had actual knowledge of the stakes or not.—Foley v. McCarthy, (Mass.) 32 N. E. 669.

16. Courses and distances must yield to the demands of an actual survey when the evidence determines the fact of such survey; so that, where the surveyor's field notes show actual surveys on the ground, and the lines and corners thereof are called for as contiguous, and evidences of such surveys are still found which reasonably indicate an excess in the distance of the lines of 260 varas in 7,116 varas, at the date of the survey, (1856,) considered trifling, and a slight variance of seventy-five varas in the course, these discrepancies should not overcome the other evidence pointing to the fact that the surveys are contiguous.—Graham v. Dewees, (Tex. Sup.) 20 S. W. 127.

17. Where a survey is made without legal authority, copies of the field notes thereof, though certified from the general land office, are inadmissible.—Von Rosenberg v. Haynes, (Tex. Sup.) 20 S. W. 143.

18. In a dispute as to the boundary line between adjoining proprietors, testimony that a former owner of the elder survey, who was one of the original surveyors of the tract and helped to locate the corners, and who has since died, pointed out to witness a certain place as a corner, is admissible.—Beal v. Asberry, (Tex. Sup.) 20 S. W. 115.

19. The expressions, "middle of the Mississippi river" and "the center of the main channel of that river," as used respectively in the enabling acts under which the states of Illinois and Wisconsin were admitted into the Union, and "middle of the main channel of the Mississippi river," as used in the enabling acts of Missouri and Iowa, all being descriptive of the boundaries of those states, are synonymous terms, and mean the middle of the main navigable channel, or channel most used, and not the middle of the great bed of the stream, as de-

fined by the banks of the river.—State of Iowa v. State of Illinois, 13 S. Ct. 239.

20. Where the description in a deed, after following the line of another tract to a certain point, contains a clause "thence with that line to a stake on the west bank of the branch," it should be construed as intending to follow the boundaries of such tract, though the courses change before reaching the branch, and though the branch would be reached at a less distance by following an extension of the first course from the point in question.—Buckner v. Anderson, (N. C.) 16 S. E. 424.

21. The locative calls in a patent, in accordance with which the survey is admitted to have been actually made on the ground, control more general calls as to the county, and the direction and distance of the land from certain well known points.—Minor v. Kirkland, (Tex. Civ. App.) 20 S. W. 932.

22. Plaintiff claimed that, under a patent granting the "east half" of a quarter section, his land extended to a north and south line dividing the quarter section in equal halves, while defendant claimed through a patent granting the west half of the quarter, "according to the official plat of the survey," which placed the division line fifteen feet east of the line claimed by plaintiff. The quarter section was fractional, and according to the official plat the west half contained ninety acres, while the east half contained but eighty. *Held*, that as the official plat controlled the identification of lands granted by government patents, plaintiff had no title to the strip of land in dispute.—Turner v. Union Pac. Ry. Co., (Mo. Sup.) 20 S. W. 673.

23. Where, in trespass to try title, there is a conflict in the calls of a railroad survey under which plaintiff claims, parol testimony is admissible to show where the metes and bounds of the surveys were actually run and marked upon the ground.—Minor v. Kirkland, (Tex. Civ. App.) 20 S. W. 932.

24. In an action to obtain possession of land, where a controversy arises as to which one of two branches is meant by a clause in a deed which states "thence with that line to a stake on the west bank of the branch," and the evidence is conflicting as to whether there is in fact any branch crossing such line at the point claimed by plaintiff, the question as to which branch was intended was properly submitted to the jury.—Buckner v. Anderson, (N. C.) 16 S. E. 424.

25. Where a controversy arises as to which one of two branches is meant by a clause in a deed which states "thence with that line to a stake on the west bank of the branch," though there be evidence that the parties agreed by parol where the true boundary ran, after the exe-

cution of the deed, it is proper for the court to refuse to instruct the jury that by such verbal agreement the parties could alter the boundaries as fixed in the deed, and would be estopped from disputing the new location so agreed upon.—Buckner v. Anderson, (N. C.) 16 S. E. 424.

26. Under Rev. St. U. S. § 2396, which provides that the boundary lines actually run and marked in the surveys returned by the surveyor general shall be established as the proper boundary lines of the sections or subdivisions for which they are intended, a resurvey made three years after a patent is issued cannot, in the absence of fraud, change the corners and boundaries as established by the original survey so as to affect the patentee's rights.—Spawr v. Johnson. (Kan.) 31 P. 664.

27. Where objects, natural or artificial, are called for in the field notes of official surveyors, the presumption is that such objects actually existed.—Kuechler v. Wilson, (Tex. Sup.) 18 S. W. 317.

28. In a deed of conveyance, the boundary lines of the granted premises, designated by courses and distances, starting from a definite place of beginning, disclosed no error or inconsistency until the last line was reached, which was to run to the place of beginning;" but the given course and distance, would not bring it to that point, nor complete the enclosure of any land. *Held*, that the course and distance of the last line should be rejected as erroneous, and effect be given to the more certain designation, "thence to the place of beginning." —Owings v. Freeman, (Minn.) 51 N. W. 476.

29. Where a fence is built between two lots on the line indicated by the first survey, and the lots are purchased in reliance on the correctness of such line, the purchasers are entitled to maintain it as a boundary, even though a subsequent survey shows it to be wrong. Flynn v. Glenny, 17 N. W. 65, 51 Mich. 580, followed.—Le Compte v. Lueders, (Mich.) 51 N. W. 542.

30. Plaintiff's predecessor in title, through mistake as to the true boundaries of land purchased by him, built his fence so as to include other land of his grantor not conveyed by the deed. The land so inclosed was occupied and cultivated by plaintiff and his predecessor as a homestead, for more than forty years. Code Civil Proc. N. Y. § 327, provides that "for the purpose of constituting adverse possession by a person claiming title not founded on a written instrument, the land is presumed to have been possessed and occupied * * * (1) where it has been protected by a substantial enclosure; (2) where it has usually been cultivated and improved." Section 368 provides that such possession for twenty years will overcome the presumption in favor of the owner of the legal title.

Held, that plaintiff has a good title by adverse possession. 12 N. Y. S. 693, affirmed, without opinion.—Eldridge v. Kenning, (N. Y. App.) 29 N. E. 1028.

31. In trespass for cutting down timber; it appeared that the division line between plaintiff and defendant had been surveyed by courses and distances; that, commencing at the point specified, and running either as claimed by plaintiff or by defendant, some of the distances, where no monuments were specified in the description, must be disregarded in order to return to the point started from. *Held*, that this raised a latent ambiguity to solve which oral testimony was admissible. —Rugg v. Ward, (Vt.) 23 A. 726.

32. In ejectment arising out of a boundary dispute, both parties claimed to a certain old line, and both relied on adverse possession; defendants contention being that there was a jog in the old line. Plaintiff having given the evidence of adverse possession for the prescriptive period, defendent introduced evidence that he himself had been in adverse possession to an old board fence, which remained upon the ground until a few years before the trial, and that this fence was located on the line of the jog claimed by him. *Held*, that it was proper for plaintiff to show in rebuttal that this fence stood upon a straight line with the rest of the boundary.—Wineman v. Grummond, (Mich.) 51 N. W. 509.

33. In ejectment arising out of a boundary dispute, where both parties claim to a certain old line, and both rely upon adverse possession, it is competent for plaintiff to introduce the title deeds for both himself and defendant, the boundary being therein described by reference to the old line by name, since they tend to show the location of the respective lots, and that the question at issue is as to the true location of the old line named therein.—Wineman v. Grummond, (Mich.) 51 N. W. 509.

34. A grant of lands bounded by navigable tidewater carries no title to land below high-water mark.—DeLancey v. Piepgras, (Sup.) 17 N. Y. S. 681.

35. Occupants of government land caused the same to be platted as a town-site, with a street along the shore of a navigable lake. Thereafter this town-site was entered and purchased, and title thereto obtained by a judge of the district court, as provided by act of congress of May 23, 1844. In the execution of his trust, said judge conveyed to one of the beneficiaries a lot fronting upon the street before mentioned, describing the same in accordance with the town plat. *Held*, that the fee title, subject to the public easement, to the entire street to low-water mark, including all the riparian rights, and not merely to the middle of the street, passed to the

grantee, and on a conveyance by him by the same description passed to his grantee.—Wait v. May, (Minn.) 51 N. W. 471.

Where monuments mentioned in a deed are identified, they control both courses and distances given, whether they were seen by the parties to the deed or not.—Anderson v. Richardson, (Cal.) 28 P. 679.

37. Where the boundaries of a survey cannot be located by its own calls and field-notes, they may be established by the field-notes of adjacent surveys.—Kuechler v. Wilson, (Tex. Sup.) 18 S. W. 317.

38. Where a junior survey was not made on the ground, and the calls are for the surrounding surveys, the lines of such surveys will be the lines of the junior survey.—Kuechler v. Wilson, (Tex. Sup.) 18 S. W. 317.

39. The mere fact that the owner of land, desiring to break it, calls upon the owner of adjoining land to point out the boundary between them, and that the latter indicates what he supposes to be the line, does not create an estoppel against such adjoining owner to claim the true line, if different from the one pointed out.—Heinz v. Cramer, (Iowa,) 51 N. W. 173.

40. On an issue as to the true location of the western boundary line of a certain claim, the evidence showed that the line contended for by defendent was identified by the first surveyor of the claim as the line run by him, which line the government surveyor followed in his survey; that it substantially agreed with the natural calls in the field-notes of the government survey; that it was traceable by marks and blazes on the trees; that it agreed substantially with the reputed line as evidenced by certain fences; and that it intersected the south-eastern corner of the claim adjoining on the west, while the line contended for by plaintiffs ran some sixty feet further east. Plaintiffs' contention was supported only by the fact that what they claimed to be the south-western corner was the north-western corner of the claim adjoining on the south, which corner was intended to be identical with the southern terminus of the line in dispute, and which was within six feet of the correct distance from the south-eastern corner of the claim on the north according to the field-notes. But the claim on the south was located subsequently to the government survey before mentioned. *Held*, that the evidence showed defendants' contention to be the true line.—Van Dusen v. Shively, (Or.) 29 P. 76.

41. In an action of trespass for cutting timber, where the location of the dividing line between the parties is relevant, the testimony of the county surveyor that he ran the line pending the suit, that defendant was present when this was done, and that a certain map of the survey is correct, is admissible evidence for plaintiff, notwithstanding the surveyor also testifies

that the work was done in the course of processioning the land in accordance with the statute on that subject.—Gunn v. Harris, (Ga.) 14 S. E. 593.

42. In ejectment arising out of a boundary dispute, where both parties claim to a certain old line, and both rely upon adverse possession, the defendant's contention being that there was a jog in this old line, it was competent for an experienced surveyor, familiar with the property, to testify that he had surveyed the line some time in the 50's and found it to correspond with certain maps then in existence, and then to testify by the aid of those maps that the line was straight, instead of containing a jog, although such maps were not shown to be authentic.—Wineman v. Grummond. (Mich.) 5 N. W. 509.

43. Where the description in a deed is by metes and bounds, which are complete in themselves, and which are so made as to exclude a certain road, a reference to the road for the purpose of designating the point from which the description starts and the course of a line therefrom does not show an intention to make the road the boundary of the land, except as it coincides with the description in the deed; and the grantee, therefore, is not entitled upon the discontinuance of the road as a public way, to claim an easement therein, as appurtenant to the premises against the grantor.—Lankin v. Terwilliger, (Or.) 29 P. 268.

44. Where there is a conflict as to the location of land by a survey, but two corners thereof can be definitely identified, the courses and distances may be ascertained from the field-notes, and the entire survey constructed therefrom; and in such case the distance and quantity must yield to course.—Rand v. Cartwright, (Tex. Sup.) 18 S. W. 794.

45. A monument established by the government surveyors as the true corner of sections will control courses and distances.—Brown v. Morrill, (Mich.) 51 N. W. 700.

46. Where, in an action to recover possession of land, the evidence is conflicting as to the true location of a station, which is described as a natural monument, and is located in a different place by the courses and distances, the natural monument will control.—Stoll v. Beecher, (Cal.) 29 P. 327.

47. Where the public have only a right of way over a public street, a conveyance of the abutting land, describing it as "bounded by" such street, includes the land to the center of the street.—Firmstone v. Spaeter, (Pa. Sup.) 25 A. 41; In re Kimber's Estate, Id.

48. Where, in a suit by certain property holders against a city, the evidence shows an uncertainty as to the direction in which one of the boundary lines of the city should run, but it appears that the boundary claimed by the city has been acqui-

esced in by both parties for over twenty years, and until the time of bringing the suit, such boundary will be considered the correct one.—Belknap v. City of Louisville, (Ky.) 20 S. W. 309.

49. A mere parol agreement of adjoining land-owners as to the boundaries between them, which changes the legal construction of the title deed, is not binding on subsequent purchasers.—Shaffer v. Hahn, (N. C.) 15 S. E. 1033.

50. Where the owners of land convey the same, bounding it by the line of a highway, parol evidence is admissible to show whether, by such description, the parties meant the surveyed line of the highway, or the line as actually used and occupied.—Wead v. St. Johnsbury & L. C. R. Co., (Vt.) 24 A. 361.

51. Where, in a suit to establish a section corner, the only objections to the commissioner's report are as to his findings, the court may, after sustaining the objections, establish the corner without again referring the case to the commissioner,—Yocum v. Haskins, 46 N. W. 1065, 81, Iowa, 437, distinguished. Doolittle v. Bailey, (Iowa,) 52 N. W. 337.

52. Where, in a suit to establish a section corner, the evidence shows that it was located at a certain point, the court should establish the corner at that point, even though such point is not equidistant from the section corners on either side of it.—Doolittle v. Bailey, (Iowa,) 52 N. W. 337.

53. The word "adjoining," in the description of premises conveyed, means "next to," or "in contact with," and excludes the idea of any intervening space. The description of the premises granted as "adjoining the Atlantic ocean," with the additional words "bounded on the ocean," carries title to the line of ordinary high water, with all the incidents of riparian ownership upon tidal waters.—Yard v. Ocean Beach Ass'n, (N. J. Err. & App.) 24 A. 729.

54. In establishing section lines, corners shown to have been originally made by government surveyors are conclusive, and shall be accepted as the true corners, no matter how inaccurately they may have been originally established.—Town of Liberty v. Burns, (Mo. Sup.) 19 S. W. 1107.

55. Where the monuments, or objects, or marks called for in a deed have been obliterated, their former site or location must be established with reasonable certainty, in order that they shall prevail over the lines established by explicitly given courses and distances, or to throw an evident error of description by courses and distances into the second boundary line as given, which otherwise would be charged to the fourth or last line, and correct the description by rejecting the given courses and distances, and bringing the last line to the terminus defi-

nitely described in the conveyance as "the point of beginning." Yanish v. Tarbox, (Minn.) 15 N. W. 1051.

56. Where there is a variance between the plat and the field-notes of the original survey of public lands, the former must control, since it represents the lines and corners as affixed by the surveyor general, and by which the land was sold.—Beaty v. Robertson, (Ind. Sup.) 30 N. E. 705.

57. In a proceeding to establish section corners it is not a misjoinder of parties plaintiff, or of causes of action to join as plaintiffs owners within the section interested in the south-west corner only, with owners interested in the north-west corner only.—Rollins v. Davidson, (Iowa,) 50 N. W. 1061.

58. In a proceeding to establish section corners it is proper to exclude evidence "tending to show that there were decrepancies between the known monuments and field-notes of surveys of other townships in the county made by the same government surveyor."—Rollins v. Davidson, (Iowa,) 50 N. .W 1061.

59. Where a creek, in a time of freshet, breaks through a narrow neck of land, and afterwards continues to flow through the new channel, separating the neck from the tract to which it originally belonged, such separation is not caused by the "wear of the creek," within the meaning of a deed which conveyed to plaintiff the tract of which such neck was a part, "less the wear of a creek."—Henning v. Bennett, (Sup.) 18 N. Y. S. 645.

60. A deed described the boundary of the land conveyed as beginning at a fixed point, and running a certain course a distance of "about" 865 feet, to a "point on" the shore of Long Island Sound; thence running "along the shore and Sound" to a certain point; and thence, by a given course, a distance of "about" 1,288 feet to the place of beginning; containing a certain number of acres "more or less." To make the distances and acreage agree with the deed, the courses would have to be run to low-water mark, and along low-water mark. *Held*, that the deed conveyed the land to low-water mark, and included the shore, notwithstanding the rule that by the shore as a monument is meant the line of high water, when the boundary is the sea.—Oakes v. DeLancy, (N. Y. App.) 30 N. E. 974.—Oakes v. Delancy, (Super. N. Y.) 15 N. Y. S. 561 affirmed.

61. The United States sold the North half of a government section to plaintiff's predecessors, and set off to the state the south half for schools, by reference to the survey and plat returned by the surveyor general. *Held*, in an action against the state's grantee, that the location of the dividing line between the north and south half must be determined from such plat and the acts of congress relating to the survey of the

public domain.—Goltermann v. Schiermeyer, (Mo. Sup.) 19 S. S. W. 484.

62. Rev. St. U. S. § 2395, provides that, where townships which are subdivided "exceed, or do not extend six miles, the excess or deficiency shall be specially noted, and added to, or deducted from the western and northern ranges of sections or half sections," and these irregular sections and half sections "shall be sold as containing only the quantity expressed in the returns and plats," and all others as containing the legal quantity. Section 2396 provides that "all the corners marked in the surveys returned by the surveyor general shall be established as the proper corners of sections or subdivisions of sections they were intended to designate; and the corners of half and quarter sections, not marked on the surveys, shall be placed, as nearly as possible, equidistant from two corners which stand on the same line." *Held*, the law making it the surveyor general's duty to calculate the areas, and state the result thereof on the plat, that it is competent for him to note thereon, as part of the plat, the distances of quarter section lines on which such calculations were based.—Goltermann v. Schiermeyer, (Mo. Sup.) 19 S. W. 484.

63. Even if the figures designating the distances on which such calculations were based should have been omitted from the plat, still, where a quarter section corner was fixed up by the surveyor general by stating the distance thereof from the section corner, and the government accepted the plat and sold the land in pursuance thereto, such acceptance through the political departments adopted the plat with all the marks and figures thereon, and is not reviewable by the courts.—Goltermann v. Schiermeyer, (Mo. Sup.) 19 S. W. 484,

64. Even if the figures designating the distances on which such calculations were based should have been omitted from the plat, a township is not made "fractional," because in laying it off into sections, there is a deficiency or excess to be carried into the western or northern range of half and quarter sections. —Goltermann v. Schiermeyer, (Mo. Sup.) 19 S. W. 484.

65. Where a section is divided by a water course, and is subdivided in lots instead of regular subdivisions, and a lot bounds on the water course, the water course itself, and not the meander lines thereof, is the proper boundary; and, if the grantee does not find the water course as called for by his patent, he may go as far as the next "eighth line" to locate his boundary.—Lally v. Rossman, [Wis.] 15 N. W. 1132.

66 Where the description in a deed contains no patent ambiguity, but, on its application to the land described, it results in a lot of the most singular shape, plainly never intended by the parties, there is no error in ignoring the calls for

courses, and applying only the calls for distance, where the land which the evidence shows was intended to be conveyed may be thereby fully identified.—Toklin v. Anderson, (Tex. Sup.) 19 S. W. 350.

67. In a suit to establish a section corner the evidence showed that all the owners of adjoining land, except plaintiff, had openly acquiesced in a certain location for the corner for more than ten years; that plaintiff had owned his land for eight years, during which time he had acquiesced in said location; that his grantor was a non-resident; and that plaintiff, when he fenced the land, built his fence according to said location of the corner. *Held*, that the evidence justified a finding that plaintiff and his grantor had acquiesced in said location of the corner for ten years.—Doolittle v. Bailey, (Iowa,) 52 N. W. 337.

68. Code Civil Proc. § 368, provides that "in an action to recover real property, * * * the person who establishes a legal title to the premises is presumed to have been possessed thereof within the time required by law, and the occupation of the premises by another person is deemed to have been under and in subordination to the legal title, unless the premises have been held and possessed adversely to the legal title for twenty years before the commencement of the action." *Held*, that in ejectment to establish a disputed boundary, where the defense is acquiescence in the line claimed by defendent, he must show such acquiescence for at least twenty years.—Clark v. Davis, (Super. N. Y.) 19 N. Y. S. 191. 28 Abb. N. C. 135.

69. In ejectment, where the quarter section of land which included the disputed territory contained sixty-seven acres more than the required number, and no subdivisional survey of such quarter section was made until 1883, when the corners were established by the county surveyor at the instance of defendant, his failure for three years to appeal from such survey made it conclusive evidence of the true location of the dividing line.—Sin v. King, (Ind. Sup.) 31 N. E. 48.

DEDICATION.

1. Where a land-owner files a map of a number of blocks owned by him, on which one block is marked "Central Park," circulates copies of the map, and states in an advertisement, and announces through an auctioneer, while selling the adjacent blocks, that such a block is reserved for a park he dedicates the park to the public.—Archer v. Salinas City, (Cal.) 28 P. 839.

2. Where a land-owner files a map of a number of blocks owned by him, on which one block is marked "Central Park," circulates copies of the map, and states in advertisement, and

announces through an auctioneer, while selling the adjacent blocks, that such a block is reserved for a park, actual acceptance is not requisite to complete the dedication, since acceptance will be presumed from the benefit arising from the dedication. People v. Reed, 22 P. 474, 81 Cal. 70, distinguished.—Archer v. Salinas City, (Cal.) 28 P. 839.

3. Where a land owner files a map of a number of blocks owned by him, on which one block is marked "Central Park," circulates copies of the map, and states in an advertisement, and announces through an auctioneer, while selling the adjacent blocks, that such a block is re-reserved for a park, failure of the public to use the dedicated land for the purpose intended does not impair the dedication, nor authorize the prior owner to resume possession.—Archer v. Salinas City, (Cal.) 28 P. 839.

4. Marking a street on the plat of a town or addition thereto, and selling lots with reference to such street, dedicates the ground so marked to the use of the public as a street, and purchasers of lots have a right to have all streets marked on the plat by which they purchased kept open.—Wolfe v. Town of Sullivan, (Ind. Sup.) 32 N. E. 1017.

5. Mary Washington was interred in a burial lot, with the consent and approval of the owner, and forty-two years thereafter a monument was erected over her grave by an association organized for that purpose. The corner stone was laid, with civic ceremonies and military pageant, by the president of the United States. *Held*, that there was a complete dedication of the tomb to public and pious uses.—Colbert v. Shepherd, (Va.) 16 S. E. 246.

6. Where the owner of a tract of land lays it out in lots and streets, and in the plan or map thereof filed with the public records designates a certain portion as "Park," and afterwards conveys lots and blocks by reference to such plan, it operates as a dedication of the land for a public park, and his successor in interest cannot, after the lapse of more than twenty years, set up as against the public a different intent.—Steel v. City of Portland, (Or.) 31 P. 479.

7. Where land outside of a city is platted as a town site, and by consent of the owners a railroad is built on a strip marked on the plat as a street, but which has never been accepted by the public as such, neither the subsequent annexation of the land to the city nor the acceptance of the strip by the authorities thereof renders the occupation by the railroad a nuisance, subject to abatement by resolution of the city council.—City of Denver v. Denver & S. F. Ry. Co., (Colo. Sup.) 31 P. 338.

8. Where one plats a townsite, and leaves a strip 100 feet

wide running through the town, which he designates on the town plat as "M. Street," and he and his grantee permit the public to use such strip as a street for ten years or more, he is estopped from denying that the entire 100 feet was dedicated, regardless of a general statement on the plat that all the streets are sixty-six feet wide.—Smith v. Montgomery, (Idaho,) 31 P. 812.

9. Where a proprietor of land lays it out in lots, which he afterwards conveys according to a plat which shows the lots are upon a street, the conveyance of the lots bounded on the street is a dedication of the land covered by the plotted street to the use of the lot owners as a means of access to their lots, and he can retain no title to such street, as against the lot owners, except by express reservation in his deed.—Dobson v. Hohenadel, (Pa. Sup.) 23 A. 1128.

10. When the owner subdivides property into city blocks, streets and alleys, marking the streets and alleys on the ground, and files the plat, and in selling and making deeds of lots describes them with reference to streets and alleys as platted, the intention to dedicate the streets and alleys is manifest, and the owner retains no interest in the same, though the plat was not acknowledged as required by statute.—Heitz v. City of St. Louis, (Mo. Sup.) 19 S. W. 735.

11. Acceptance and user by a city of a street or a portion of a street as platted is equivalent to acceptance of the whole tract platted. Heitz v. City of St. Louis, (Mo. Sup.) 19 S. W. 735.

DEED.

1. Where the courses and distances given in a deed conveying a lot show it to contain 9,101 square feet, instead of only 7,770, as stated in the deed, evidence that the grantee of an adjoining lot, claiming under the same grantors, built a fence on the line, as he supposed it to be, between his lot and the one in question, is not admissible to control the description of the line in the first deed.—Hall v. Eaton, 29 N. E. 660, 139 Mass. 217.

2. Where the courses and distances given in a deed conveying a lot show it to contain 9,101 square feet, instead of only 7,770, as stated in the deed, evidence that the grantors had made a plat of the land, and that this plat showed the lot to contain 7,770 square feet, is inadmissible to control the deed, when the deed does not refer to the plat, and it does not appear that the plat was shown to the grantee.—Hall v. Eaton, 29 N. E. 660, 139 Mass. 217.

3. Where the courses and distances given in a deed conveying a lot show it to contain 9,101 square feet instead of only

7,770, as stated in the deed, evidence that the grantors deeded other lots adjoining the one first granted, with descriptions showing that the first lot was intended to contain only 7,770 square feet, is inadmissible.—Hall v. Eaton. 29 N. E. 660, 139 Mass. 217.

4. For the purpose of identifying and locating artificial monuments in a deed to plaintiff, the court admitted in evidence a written contract to convey, made by a former owner of the land in dispute, together with parol testimony showing that in pursuance of the contract, the monuments in question were located by a surveyor, and that the descriptions in the deed to plaintiff's predecessor were made from the report of the surveyor. Evidence was also admitted, by one of the surveying party, as to the location of the monuments. *Held*, that all this evidence was competent.—Anderson v. Richardson, (Cal.) 28 P. 679.

5. How a deed should be construed, with a reference to a proper location of it, or what was the proper location of a particular deed, having reference to other deeds in the case, is a question of law, for the court; and it is not competent for a surveyor to give an opinion concerning such a question.—Kelso v. Steiger, (Md.) 24 A. 18.

6. The east line of a highway, as actually used and occupied, extended further east than the line as surveyed. Adjoining lands were conveyed with reference to the former line. *Held*, that the grantees as against the grantors acquired, no title to the lands lying between such lines, and on a taking of the same for a railroad right of way, the grantors are entitled to compensation.—Wead v. St. Johnsbury & L. C. R. Co., (Vt.) 24 A. 361.

7. The words "one acre, being the south-east corner of the north-east quarter," etc., contained in a sheriff's deed, without further descriptive words, are sufficiently certain, and mean an acre in a square form in the corner.—Smith v. Nelson, (Mo. Sup.) 19 S. W. 734.

8. In a deed of the "east half" of a fractional quarter section, the words "east half" refer to the government subdivision of a quarter section, and not to a subdivision of the quarter section by a line dividing it into two equal parts.—Turner v. Union Pac. Ry. Co., (Mo. Sup.) 20 S. W. 673.

9. A description in a deed, "west part N. E. quarter, N. W. quarter twenty acres," of a certain section, is sufficiently definite, the words "twenty acres" showing the words "west part" to mean "west half."—Soukup v. Union Inv. Co., (Iowa) 51. N. W. 167.

10. A deed purporting to convey a piece of land one acre square, beginning at a specified corner of an eleven-acre tract

described in a deed from P. to O., recorded on a specified page of a specified public record, to agree with the metes and bounds made by one C., sufficiently identifies the land.—Overand v. Nenczer, (Tex. Sup.) 18 S. W. 301.

11. The owner of a farm of 300 acres, in which was a garden 100 feet square, immediately behind his house, granted a railroad company a right of way across his farm, "provided the road runs at back of garden." This clause was inserted in the deed because the grantor was dissatisfied with a preliminary survey which had made the line of the road run through the garden. *Held*, that the deed gave the company no right to construct its road through the garden.—Knoxville, C. G. & L. R. Co. v. Beeler. (Tenn.) 18 S. W. 391.

12. Where a deed describes the tract conveyed as bounded, north fifty-six feet by a certain street, "east two hundred feet by other land of said grantors on a passage-way," south fifty-six feet by certain land, and west two hundred feet by another street, but it appears that no passage-way in fact exists, the deed is to be construed as conveying a tract fifty-six feet wide, irrespective of the passage-way mentioned.—Treat v. Joslyn, 29 N. E. 653, 139 Mass. 94.

13. In an action to establish a disputed boundary line, it appeared that the person from whom plaintiff derived title, settled on the public domain with the intention of acquiring three hundred and twenty acres thereof. He finally received a certificate therefor, in which the land was described only by courses and distances from an initial point, and as so described contained 322.89 acres. On this certificate a patent was issued. In neither patent nor certificate were any monuments referred to, except the initial point. The east line of this tract corresponded with the west line of defendant's land, which line was recognized for many years as the true division line by the owners on either side, until a survey was made, in which were found what are claimed to be the original stakes set by certain government surveyors, which would carry the division line 3.88 chains east, and give plaintiff twenty-seven more acres than are called for by the government patent. The courses and distances given in the field-notes of this government survey corresponded with those given in the patent. *Held*, that the boundary line was as fixed by the certificate and patent.—Hale v. Cottle, (Or.) 28 P. 901.

14. Where a deed describes the lot conveyed as bounded by certain lines, beginning at a corner on a certain street, "thence northerly * * * 134 feet; * * * thence westerly * * * 60 feet; thence southerly, * * * at right angles" to the street of beginning, 125 feet; thence easterly on said street, 61 feet, more or less, to the first mentioned bound,

containing 7,770 feet, more or less,"—the third line must be drawn at right angles to the street mentioned, though this will make the fourth line 80.52 feet long, instead of 60.5 feet, and the whole lot will contain 9,101 square feet, instead of 7,770.—Hall v. Eaton, 29 N. E. 660, 139 Mass. 217.

15. A deed of unimproved land "estimated" as 200 acres, described the boundaries as "beginning at two birches on Simmons creek, corner to A's land; and running thence up said creek with M's line, S., 55° W., 120 poles, to six chestnuts, corner to M's survey; and with the same S., 35° E., 310 poles, to a double and single poplar, corner to A.; and with the same N. 40° E., 250 poles to the beginning." *Held*, it being apparent that in running the lines in the reverse direction all the calls would be satisfied, and the ambiguity would disappear, such course should be adopted, especially as such boundaries were natural, rather than a construction which would entirely ignore Simmons creek," "Miller's line," the course "S. 55° W." and the distance "120 poles," notwithstanding that the lines so run in the reverse direction would include 375 acres.—Simmons creek Coal Co. v. Doran 12 S. Ct. 239.

16. In a written obligation to convey certain real estate, it was described as N. ½ of S. E. ¼, of section 3, in a given township and range, "less twenty-five acres off the south side." *Held*, that *prima facie* the description manifested the intention to lay off twenty-five acres in a parallelogram, with the whole of the south line of the N. ½ of the quarter section in question as its base.—Watson v. Crutcher, (Ark.) 19 S. W. 98.

17. Certain lots conveyed were described by numbers according to the grantor's plat, and also as one piece of land, bounded by "the Philadelphia & Norriston Railroad," which appeared on the city plan of streets as a plotted street 120 feet wide, in the center of which was a railroad right of way 66 feet wide, with a strip 27 feet wide on each side thereof, intended by the city as a public street. The grantor, in making his plat, adopted the line of this street, and many of his lots including those conveyed fronted thereon. *Held*, that the grantee's title, as against the grantor, extended to the middle of the street, subject to the existing rights of the railroad, the city, and the owners of lots in the grantor's plat.—Dobson v. Hohenadel, (Pa. Sup.) 23 A. 1128.

18. The fee of the streets of the city of Richmond is in the abutting owners, subject to the lawful use of the streets by the city. Telegraph Co. v. Williams, 11 S. E. 106, 86 Va. 700, and Hodges v. Railroad Co., (Va.) 14 S. E. 380, followed.—Page v. Belvin, (Va.) 14 S. E. 843.

19. A deed is sufficient which describes the land as being on a particular stream in a designated parish, adjoining certain

named properties, or upon the stream upon which it is situated within the parish designated, with the number of acres it contains, referring to the conveyance by which the vendor acquired it; errors in the description by legal subdivisions being cured by other descriptive designations, which leave no doubt of the particular tract that was intended to be sold.—Bryan v. Wisner, (La.) So. 290.

20. A deed described the land conveyed as beginning at a certain rock, and running thence one mile east, one mile north, one mile west, and one mile south to place of beginning, and also stated that it was the land set off to a certain Indian under a treaty with the government. The Indian had previously selected his land as "a tract one mile square, the exact boundaries of which may be defined when the surveys are made." After the deed was given, the Indian's land was located and patented so as to include four distinct but adjacent parcels, no part of which lay within the boundaries named in the deed. *Held*, that the deed was not a float, but attached to the described lands, and in the absence of mistake could not be construed to pass title to any of the patented lands.—Duluth Storage and Forwarding Co. v. Prentice, (Cir. Ct.) 50 F. 878.

21 Act Cong. 1848, establishing the territorial government of Oregon, and providing (sections 1—6) that to every white male citizen of the United States, emigrating to, and settling in said territory between certain dates, are granted, if single, 160 acres of land, if he shall reside on and cultivate said land for the space of four years, is a grant, and, when the grantee has qualified himself by a four-years residence and cultivation to receive the title, it immediately vests in him, though he has made no final proof, such proof being simply evidence that the grantee is entitled to a patent.—Roeder v. Fouts, (Wash.) 31 P. 432.

22. Defendants' grantor bought a tract of land described as beginning 10 chains south of the N. E. corner of a certain quarter section, running thence south 5 chains and west 10 chains so as to include 5 acres. He then platted into lots 30 feet wide, the N. ½ of the S. E. ¼ of the N. E. ¼ of said quarter section. As the quarter section contained more than 160 acres, the north line of the platted land was three feet south of the deeded land. *Held*, that a purchaser of one of the northern tier of lots, whose deed simply called for the lot by number, and who had actual notice that there was a three-foot strip north of his lot, and who had possession of 30 feet without said strip, took no title to said three-foot strip.—Mendel v. Whiting, (Ill. Sup.) 31 N. E. 431.

23. In an action by the grantee in a deed running "to a point" in Long Island Sound, to recover for a deficiency in

the acerage of the land conveyed, on the ground that the deed could only convey to the high-water line of the shore, it will not be presumed, in the face of the description in the deed definitely calling for the low-water line as the boundary, that the grantor had no title to the shore, since the common-law rule that the title to the shore is in the state does not exclude the possibility of title in the grantor derived from the state or by prescription.—Oakes v. De Lancey, (Sup. N. Y.) 15 N. Y. S. 561, affirmed.—Oakes v. DeLancey, (N. Y. App.) 30 N. E. 974.

DRAINAGE.

1. Where the court acquired jurisdiction over the subject matter by the filing of the petition, and jurisdiction over the person of the land owners by giving the statutory notice, the fact that ten days did not intervene between the time the proceedings were docketed and the time at which the court referred the petition to the drainage commissioner, will not render such proceedings void.—McBride v. State, (Ind. Sup.) 30 N. E. 699.

2. The fact that the surface of the land at the mouth of a sewer is lower than at its beginning does not prove that the sewer carries the water according to its natural drainage, where it appears that the land between the two points is so elevated that the sewer had to be sunk nine feet in order to secure a proper fall.—Dierks v. Commissioners of highways Tp. Addison, (Ill. Sup.) 31 N. E. 496.

3. Laws 1883, p. 139, §8, which authorizes commissioners of highways to enter upon land adjacent to any highway, for the purpose of opening drains or ditches to carry off the water from the highway, or drain any slough or pond on such highway, does not authorize them to enter land adjacent to a highway for the purpose of carrying over such land the sewage deposited on such highways by the drains of an incorporated village.—Dierks v. Commissioners of Highways Tp. Addison, (Ill. Sup.) 31 N. E. 496.

4. The circuit court has jurisdiction of the construction of drains, and objections to its assumption thereof in a specific case must be made directly by appeal, and a party cannot, after judgment, make collateral objection to its authority to direct the construction of a particular drain, which it has assumed, by holding the petition sufficient to give the jurisdiction.—Perkins v. Haywood, (Ind. App.) 31 N. E. 670.

5. Pub. Acts 1885, c. 227, subc. 3, § 12, provides that in case a jury, impaneled to ascertain the compensation to be made for land taken for a public drain, shall decide such drain to be unnecessary, they shall so state in their return, and the drain commissioner shall thereupon dismiss the proceedings,

and no further application for the same object shall be entertained within one year thereafter. *Held*, that the statute does not apply where the jury are discharged by reason of their failure to agree, and in such case a new jury may be impaneled without waiting a year.—Morse, C. J., dissenting. Kress v. Jackson Probate Judge, (Mich.) 52 N. W. 728.

6. Elliot, Supp. § 1193, empowering a county surveyor to levy assessments to keep public ditches in "repair," does not empower him to construct new ditches.—Romack v. Hobbs, (Ind. Sup.) 32 N. E. 307.

7. The question as to what is the most available route for the location of a ditch is one for the judgment of the drainage commissioners, and their action in making such location is not subject to review on appeal, in the absence of fraud.—Chandler v. Beall, (Ind. Sup.) 32 N. E. 597.

8. Where surface water habitually flows off over a fixed and determininate course, having reasonable limits as to width, so as to be uniformly discharged at a definite point, though without having worn out a channel having definite and well-marked banks, the line of flow is a water course, within the meaning of Rev. St. 1891, c. 42, § 78, which declares that owners of land may drain the same "into any natural water course."—Lambert v. Alcorn, (Ill. Sup.) 33 N. E. 53.

9. Substituting an underground tile drain for natural surface drainage over the same land is not an abandonment of the natural water course.—Lambert v. Alcorn, (Ill. Sup.) 33 N. E. 53.

10. The owner of land adjoining a highway has no right to drain his land into a ditch in such highway by means of a drain which carries the water in a different direction from its natural flow.—Davis v. Commissioners of Highways, (Ill. Sup.) 33 N. E. 58.

11. Rev. St. 1891, c. 42, §117, declares that owners of land outside a drainage district, who connect their ditches with those of the district, shall be deemed to have applied to be included in the district. *Held*, that the owners of such lands having, by connecting with the district ditches, voluntarily consented to the inclusion of their land in the district, are not entitled to notice of the order of the commissioners' changing the boundaries of the district so as include their lands. Commissioners v. Griffin, 25 N. E. 995, 134 Ill. 330, distinguished.—People v. Dornblazer, (Ill. Sup.) 32 N. E. 688.

12. Rev. St. 1891, c. 42, § 117, declares that owners of land outside a drainage district, who connect their ditches with those of the district, shall be deemed to have applied to be included in the district, and that their lands benefitted thereby *shall* be treated, classified, and taxed as other lands in the dis-

trict. *Held*, that the fact that a drainage district lies wholly within one township, and the highway commissioners are ex officio the drainage commissioners, does not prevent them from taxing for drainage purposes land in another township, which has been by its owners connected with the drains of said district, since in levying such taxes the commissioners act as officers, not of the township, but of the drainage district.—People v. Dornblazer, (Ill. Sup.) 32 N. E. 688.

13. A ditch was opened on plaintiff's land in 1882 by the order of the supervisor. The statutes provided for an assessment of damages in such cases, to be made by three electors appointed by the supervisors, and from their award there was no appeal. Laws 1885, c. 46, amended the statute by allowing an appeal to the circuit court. Subsequent to the amendment appraisers were appointed, who found that plaintiffs were not damaged by opening the ditch. *Held*, that plaintiffs were entitled to appeal from the award, since the act of 1885 was remedial, and did not interfere with vested rights.—Smeaton v. Austin, (Wis.) 51 N. W. 1090.

14. Where a railroad company constructs a ditch along its right of way, whereby it diverts surface water from the direction in which it naturally flows, and overflows land on the natural water course into which the water so diverted is finally emptied, the company is liable for the damage, though the ditch was necessary to the operation of the road and it was carefully constructed. Jenkins v. Railroad Co., 15 S. E. 193, 110 N. C. 438, followed.—Staton v. Norfolk & C. R. Co., (N. C.) 16 S. E. 181.

15. The question of the practicability of a route to be selected for a public ditch is in the discretion of the inferior tribunal or its officers, and cannot be reviewed on appeal.—Sample v. Carroll. (Ind. Sup.) 32 N. E. 220.

16. The selection of the line of a former ditch is not an abuse of such discretion.—Sample v. Carrol, (Ind. Sup.) 32 N. E. 220.

17. Since drains constructed under Act March 9, 1875, were not especially constructed under the supervision of the commissioners charged with their establishment, the county surveyor was not obliged to wait until such drains were entirely completed before having them repaired, as commanded by Elliott's Supp. 1889, § 1193, but might take possession, for that purpose, of the completed portions.—Artman v. Wynkoop, (Ind. Sup.) 31 N. E. 468.

18. Where a county commissioner, in determining the necessity for taking certain land for a drain, neglects to specify the size and location of the drain, as required by statute, or in case a jury is demanded, to issue a *venire* describing the

land, the proceedings are so defective that no legal drain can be laid, and a township supervisor, therefore, may lawfully refuse to assess a tax.—Nugent v. Erb, (Mich.) 51 N. W. 282.

19. Where a drain commissioner made his apportionment of benefits for a drain, and assessed twenty-seven per cent. of the cost on three forties of land as belonging to T., and thereafter, on learning that J. owned one of the forties, made out his assessment roll for the supervisors, dividing such cost in proportion to the acreage, and placing one-third of the amount on J.'s forty, it was an irregularity which justified the supervisors in refusing to spread the tax on such forty. —Tinsman v. Board of Supervisors, Monroe County, (Mich.) 51, N. W. 460.

20. The fact that a land-owner appeared before the commissioners appointed to assess damages and benefits for a drain, and accepted the award of damages to part of his lands, and entered into a contract to construct the drain through such lands, did not estop him from objecting to an irregularity in assessing another parcel, where he had no knowledge that such other parcel had been assessed until the assessment roll was completed, at which time it was too late to appeal from the act of the commissioners.—Tinsman v. Board Supervisors, Monroe County, (Mich.) 51 N. W. 460.

21. Though laws of Indiana provide that ditch assessments shall be made by the county surveyor, and appeals therefrom prosecuted against him, the county only is financially interested in the collection of the assessment, and is entitled to defend in the name of the county surveyor, or to employ attorneys to appear for the county surveyor and resist the appeal.—Stingley v. Nichols, Shepherd & Co., (Ind. Sup.) 30 N. E. 34.

22. A county surveyor cleaned out a public ditch and its arm, and warrants were drawn on the county treasurer to pay therefor. An assessment was afterwards made on the landowners along the ditch to reimburse the county, from which assessment they appealed. The appeal-bonds were made payable to the county surveyor, instead of the deputy-surveyor, who made the assessment. The lands assessed were not described therein, nor was it stated whether the repairs were to the main ditch or its arm. *Held* immaterial.—Stingley v. Nichols, Shepherd & Co., (Ind. Sup.) 30 N. E. 34.

23. Upon proceedings to assess benefits of a proposed extension of a ditch, the fact that certain lands in the drainage district are sufficiently drained by the ditch without an extension is no objection to assessing such lands on account of the extension.—Briggs v. Union Drainage District, (Ill. Sup.) 29 N. E. 721.

24. Land not assessed for the construction of a ditch cannot be assessed for repairs, under the express provisions of Elliott Supp. § 1193.—Scott v. Stingley, (Ind. Sup.) 31 N. E. 953.

25. On appeal to the circuit court from assessments levied by the county surveyor for the repair of a ditch, appellants cannot escape liability on the ground that no additional assessments had been levied against other land-owners, who had permitted the cattle to obstruct the ditch, where appellants made no effort to prove the additional cost of removing such obstruction so as to enable the court to adjust the assessments.—Scott v. Stingley, (Ind. Sup.) 31 N. E. 953.

Under Elliott Supp. §1193, which requires the county surveyor to keep the ditches in his county in repair, the surveyor is the judge of the means to be employed to accomplish the work, and land-owners cannot escape liability on assessments because the workmen employed were paid by the day, and no competition was invited.—Scott v. Stingley, (Ind. Sup.) 31 N. E. 953.

27. The fact that a county surveyor, in repairing a ditch, exceeded the jurisdiction conferred on him by Elliott, Supp. § 1193, in that he widened the bottom of the ditch beyond the original specifications, does not relieve the land-owners from paying for benefits received by the performance of such work as was within the jurisdiction of the surveyor; and where the assessments levied are short of the amount actually paid by the county for the repairs, the supreme court on appeal will presume, in the absence of evidence to the contrary, and in favor of the findings of the lower court sustaining the assessments, that appellants' lands were not assessed in an amount greater than their just proportion of legitimate costs of repairing the ditch.—Scott v. Stingley, (Ind. Sup.) 31 N. E. 953.

HIGHWAYS.

1. Where it is necessary for a commissioner of highways, in the discharge of his public duty, to shut off the water from a mill in order to repair a culvert forming part of an artificial water course or tailrace, passing under a public street, and the repairs are prosecuted with diligence and reasonable care, the commissioner is not liable for damages for the loss of power to the mill pending such repairs.—Kerr v. Joslin, (Sup.) 20 N. Y. S. 929.

2. A highway which, after having been opened and used beyond the memory of any living man, is found not to conform precisely to the original survey, can only be changed by proceedings under the road laws; and until such proceedings are had the abutting owners cannot be compelled to conform

to the survey, or to remove improvements not within the highway as theretofore existing.—Hancock v. Borough of Wyoming, (Pa. Sup.) 24 A. 88.

3. The fact that a strip of land conveyed to a city for highway purposes, while extending from a public street, terminates on private land, and does not connect with any other street or public place, does not take it out of the operation of Pub. St. c. 64, §25, relating to conveyances for highway purposes, since a cul de sac may be a highway. Simmons v. Mumford, 2 R. I. 172, 184, distinguished and doubted.—Greene v. O'Connor, (R. I.) 25 A. 692.

4. Where a town has been laid out, and one of the streets, as originally marked, used by the public for forty-five years, mere nonuser of a portion of such street, occasioned by being fenced in with abutting property, for forty years, will not constitute an abandonment by the public.—Wolfe v. Town of Sullivan, (Ind. Sup.) 32 N. E. 1017.

MUNICIPAL CORPORATIONS.

1. Const. art. 16, § 8, declaring that "municipal and other corporations invested with the privilege of taking property for public use shall make just compensation for property taken or destroyed by the construction or enlargement of their works or improvements," does not give the owner of private property a right of action against a city for injury caused his property by the construction of a sewer inadequate to carry off the water, whereby the water is banked up and backed upon his property, where the construction of the insufficient sewer is due to a mistake of judgment on the part of the city authorities, and not to an improper construction of the sewer.—Bear v. City of Allentown, (Pa. Sup.) 23 A. 1062.

2. Where a city, under legislative authority, constructs, in the bed of a stream, a covered sewer, which in ordinary storms is sufficient to carry off the water, it will not be liable, if by reason of an extraordinary storm, the sewer becomes clogged, and causes the water to overflow,and injure adjoining property. Fair v. City of Philadelphia, 88 Pa. St., 309, and Collins v. City of Philadelphia, 93 Pa. St. 272, followed.—Fairlawn Coal Co. v. City of Scranton, (Pa. Sup.) 23 A. 1069.

3. Where the necessary effect of digging a ditch is to throw water from the public street upon the land of a private person, the municipality that digs the ditch is not relieved of liability for damage done by such water by the fact that the ditch was dug upon the land of a third person with that person's consent.—Wier v. Borough of Plymouth, (Pa. Sup.) 24 A. 94.

4. It is proper to refuse to instruct the jury that, in the absence of clear proof that water running from the street upon

plaintiff's lot was the sole cause of the injury, plaintiffs are not entitled to recover.—Weir v. Borough of Plymouth, (Pa. Sup.) 24 A. 94.

5. Act May 16, 1891, (P. L. 75,) § 8, providing for the appointment of viewers to assess the cost of street improvements in cities "on the property benefitted, according to benefits, if sufficient can be found, but if not," that "the deficiency, when finally ascertained, shall be paid by the municipal corporation," does not deprive the city of the general power to make such improvements at the expense of the city, and the council of a city may set apart, out of the general revenue, sufficient money to pay for the construction of a sewer.—Commonwealth v. George, (Pa. Sup.) 24 A. 59; Id. 61.

6. The committee of the common council of the city of Richmond on streets undertook to change the grade of a street without the authority of the common council. *Held*, that the council had no power to validate the acts of the committee, in the premises, by subsequent ordinance.—Page v. Belvin, (Va.) 14 S. E. 843.

7. The recorded resolution of the committee on streets, their report to the common council, and a resolution of the council founded thereon, referred only to the relaying of gutters in the street in question. *Held*, in an action in trespass for changing the grade, that the testimony of the members of the council was improperly admitted to show that the council in fact ordered the grade of the street to be changed.—Page v. Belvin, (Va.) 14 S. E. 843.

8. Under Const. art. 16, § 8, which declares that municipal corporations "shall make just compensation for property taken, injured, or destroyed by the construction or enlargement of their works, highways, or improvements," plaintiff, who has built a house on his lot in conformity with the existing physical grade of an old public highway in front of the lot, may recover from the city damage to the lot resulting from a change in the grade.—O'Brien v. City of Philadelphia, (Pa. Sup.) 24 A. 1047.

9. Where a city changes the grade of the street, it is not liable to an abutting lot owner for damages resulting therefrom to a house erected on the lot after the change in grade was authorized.—Groff v. City of Philadelphia, Pa. (Sup.) 24 A. 1048.

10. Where a street was laid out on the official plans of the city when plaintiff purchased an abutting lot, and was thereafter dedicated for highway purposes by a proper deed, and subsequently thereto was opened and graded by the city, the city is liable to plaintiff for any damages occasioned thereby. —Hobson v. City of Philadelphia, (Pa. Sup.) 24 A. 1048.

11. Rev. St. 1891, c. 24, art. 9, § 1, authorizes cities and villages to make "local improvements by special assessment, or by special taxation, or both, of contiguous property, or by general taxation, or otherwise, as they shall by ordinance prescribe." Section 2 requires the ordinance providing for such an improvement to "prescribe whether the same shall be made by special assessment, or by special taxation of contiguous property, or general taxation, or both. *Held*, that a city could not combine general taxation, special taxation, and special assessment in making a single improvement.—Kuehner v. City of Freeport, (Ill. Sup.) 32 N. E. 372.

12. Laws 1867, c. 479, (Dunkirk Village Charter,) tit. 12, provided that the village trustees should publish a resolution of its intention to construct a sewer, and give an opportunity for the hearing of objections before ordering the sewer to be built. Title 13 authorized the trustees to order the paving or grading of a street, and caused the expense to be assessed, but required no adoption or publication of intention to pave or grade the street. Laws 1880, c, 19, changed the village into a city, and amended the charter of 1867. Title 12 of the charter as amended consolidated the provisions for constructing sewers with those for grading and paving streets, and provides that, whenever the common council of the city may deem it necessary to construct a sewer or to grade or pave a street, it may declare by resolution its intention to do so, and order the work to be done; but it does not provide for publishing the resolution or for hearing objections. *Held*, that the provisions of the village charter of 1867 as to publication and opportunity to object, if in force at all under the repealing clause of the city charter of 1880, is only in respect to constructing sewers, and does not apply to paving streets.—Lake Shore & M. S. R. Co. v. City of Dunkirk, (Sup.) 20 N. Y. S. 596; New York, L. E. & W. R. Co. v. Same, Id.

13. The charter of Duluth provides that the board of public works shall, subject to the approval of the common council, establish a system of grades for all streets, avenues, and alleys within the corporate limits for which grades have not been heretofore established, and that, to change a grade once established, there must be a resolution of the council, passed by a vote of two-thirds of the members-elect. *Held*, that it was the intention of the legislature to require the permanent grade to be established before any proceedings for the permanent improvement of a street at the expense of the real property should be commenced.—State v. Judges of District Court of Eleventh Judicial District, (Minn.) 53 N. W. 800.

14. An agreement was made by a city with a railway company not to oppose before the railroad commissioners certain

changes which the company desired to make on its line through the city, by which it would partly cut off travel on several streets, the consideration being that the company would pay the property owners on such streets whatever damage their property suffered. The contract was entered into at the request of the owners of the property for their benefit and protection. *Held*, that the contract was against public policy, and void, since it was made by public officials in consideration of private benefit to certain individuals, and no provision was made by which the public was recompensed for its loss of the right of travel through the street.—City of New Haven v. New Haven & D. R. Co., (Conn.) 25 A. 316.

15. A village, being responsible for injuries caused by defects in its streets, and being charged by law with the duty of keeping them in repair, may maintain an action to prevent them from being torn up or excavated.—Waukesha Hygeia Mineral Spring Co. v. Village of Waukesha (Wis.) 53 N. W. 675.

16. Under a village charter giving control over the public streets, and power to pass any ordinance "usual or necessary for the well-being of the inhabitants," the village may limit the time trains may block a street crossing.—Burger v. Missouri Pac. R. Co., (Mo. Sup.) 20 S. W. 439.

17. The location of a sewer in a city street must be reasonable, with respect to the rights of a street railway, the construction of which was authorized by a prior ordinance, and whose property might be damaged by such sewer; and such location, if made in a part of the street occupied by the railway, so as to compel it to suspend operations, and inflict great damage upon it, is unreasonable, when other parts of the street are equally suitable for the sewer.—Clapp v. City of Spokane, (C. C.) 53 F. 515.

RAILROADS.

1. In an action to recover damages for an overflow, caused, as alleged, by the construction of an embankment across one branch of a water course, an instruction that no recovery can be had if the jury "find from the evidence that the damage complained of was due to an overflow, caused by an extraordinary rainfall or flood," is misleading and properly refused. —Ohio & M. Ry. Co. v. Webb, (Ill. Sup.) 32 N. E. 527.

2. In an action against a railroad company for damages resulting from the construction of a solid embankment so as to obstruct the natural flow of a stream, an instruction that "it is the duty of a railroad company to construct and maintain its road across streams and natural water courses which it intersects so as to inflict no injury upon adjacent lands," is not too

broad, as stating it to be the duty of the railroad company to inflict no injury whatever, when it is made plain by other instructions, and the allegations and proofs in the case, that it was sought to hold the defendent liable only for injury which might have been avoided by the proper construction of an embankment with culverts.—Ohio & M. Ry. Co. v. Thillman, (Ill. Sup.) 32 N. E. 529.

3. In an action against a railroad company for damages resulting from the construction of a solid embankment so as to obstruct the natural flow of a stream, it is not error to instruct the jury that it is the duty of a railroad company to construct and maintain its road across streams so as to inflict no injury on adjacent lands, and that "this duty is a continuing one, and each overflow caused by the negligence or want of skill of the company creates a new cause for damages to the crops or other property of the rightful possessor of the lands overflowed."—Ohio & M. Ry. Co. v. Thillman, (Ill. Sup.) 32 N. E. 529.

4. Where, in the construction of a railroad, a stream is turned from its natural course, and made to pass under the track in the channel of another stream, merely for the purpose of diminishing expense, the company will be liable in damages for overflow caused thereby above the point of original intersection of the streams, as well below as above the track, though the water-way under the track furnished ample room for the passage of the water in time of freshet.—Adams v. Durham & N. R. Co., (N. C.) 14 S. E. 857.

5. Where a railway company builds its road through a fenced pasture, and fails to erect and maintain cattle guards at the entrance and exit of its road to and from the pasture, as required by statute, the owner may recover damages for the loss of the pasture, or, if he put his animals therein, to reasonable compensation for his efforts in preventing them from straying from the pasture, and injuring the crops on his own premises, or from trespassing on the lands of other persons. Railway Co. v. Behney, 28 P. 980, 48 Kan.—followed.—Nelson v. St. Louis & S. F. Ry. Co., (Kan.) 30 P. 178.

RIPARIAN RIGHTS.

1. Where the mainland on both sides of a stream and an island dividing the stream have been surveyed and sold by the government as separate parcels, the *filum aquae* is established in the center of the channels on both sides of the Island, between it and the mainland, as though two distinct streams existed; and where the owner of the island also owns the mainland on one side of the stream, for hydraulic purposes he is entitled to the use of the entire natural flow of water in the

channel on the side of the island on which he owns the mainland, and one-half of the flow on the opposite channel.—West v. Fox River Paper Co., (Wis.) 52 N. W. 803.

2. The title to land over which the tide ebbs and flows is in the state, and a conveyance thereof vests the absolute title in the grantee.—Bowlby v. Shively, (Or.) 30 P. 154; Hogg v. Davis, Id. 160.

3. Where a meandered lake is "non-navigable," in fact, the patentee of the riparian land takes the fee to the center of the lake; but, if the lake is "navigable" in fact, its waters and bed belong to the state in its sovereign capacity, and the riparian patentee takes the fee only to the water line, but with all the rights incident to riparian ownership on navigable waters, including the right to accretions or relictions formed in front of his land by the action or recession of the water.—Lamprey v. Metcalf, (Minn.) 53 N. W. 1139.

4. When the United States has disposed of the lands bordering on a meandered lake, by patent, without reservation or restriction, it has nothing left to convey, and any patent thereafter issued for land forming the bed, or former bed of the lake, is void and inoperative.—Lamprey v. Metcalf, (Minn.) 53 N. W. 1139.

5. Where the United States has made grants without reservation or restriction of public lands bounded on streams or other waters, the question whether the lands forming the beds of the waters belong to the state, or to the owners of the riparian lands, is to be determined entirely by the law of the state in which the lands lie.—Lamprey v. Metcalf, (Minn.) 53 N. W. 1139.

6. The owner of a city lot bounded on one side by a street which is located along a river, is not entitled, as a riparian proprietor, to land formed by accretions on the opposite side of the street.—Lebeaume v. Poctlington, 21 Mo. 36, and Smith v. Public Schools, 30 Mo. 294 followed.—Ellinger v. Missouri Pac. Ry. Co., (Mo. Sup.) 20 S. W. 800.

7. A vender who sells the entire estate owned by him up to the line of a public road bordering a river, and beyond which no property susceptible of private ownership exists at date of sale, retains no estate to which the accessory right to future alluvion can attach; and since the purchaser must bear the loss in case of any encroachment by the river, he is entitled to the alluvion on the equitable principle that "qui sentit onus, sentire debet et commodum."—Succession of Delachaise v. Maginnis, (La.) 11 So. 715.

8. The intervention of a public road between an estate and the river, does not prevent the owner of the estate from being considered as the front or riparian proprietor, when

nothing susceptible of private ownership exists between the road and the river.—Succession of Delachaise v. Maginnis,(La.) 11 So. 715.

9. Where the owner of "Rice's Point," on Duluth bay, platted it into blocks and streets, some of the blocks being entirely out in the water, beyond, and in front of the shore block, he indicated his intention to separate the shore block from the submerged blocks, and a deed of the former, according to the plat, conveys no interest in the latter.—Gilbert v. Eldrige, 59, N. W. 679, 47 Minn. 210, followed.—Bradshaw v. Duluth Imperial Mill Co., (Minn.) 53 N. W. 1066.

10. The right of the riparian proprietor on navigable waters to reclaim and occupy the submerged lands out to the point of navigability may be separated from the shore land, and transferred to one having no interest in the parent riparian estate.—Bradshaw v. Duluth Imperial Mill Co., (Minn.) 53 N. W. 1066.

11. The fee in the streets, alleys, commons, and public grounds, as exhibited on the maps of the subdivision of fractional sections ten and fifteen, lying on the lake front of Chicago, is vested in the city, together with the riparian rights appertaining thereto; and these rights were not divested by the fact that the Illinois Central Railroad occupied the lands underlying the immediate front, and filled them in for its right of way, under authority of a city ordinance; and the city still has the right to exercise such riparian rights, subject to the terms of the ordinance and to the authority of the state to prescribe the lines beyond which no structures may be extended, and also subject to such supervision and control as the United States may lawfully exercise. 33 F. 730 affirmed.—Illinois Cent. R. Co. v. State, 13 S. Ct. 110; City of Chicago v. Illinois Cent. R. Co., Id.; State v. Illinois Cent. R. Co., Id.

12. An island in a lake, proved to have existed as such prior to the survey of 1851, though not then platted, and by process of accretion since become joined by a spit to a neighboring lot, is not a portion of that lot.—Bigelow v. Hoover, (Iowa,) 52 N. W. 124.

13. Alluvion deposited against an island in a lake and a neighboring lot, so as to connect them, must be equally divided between the owners of both.—Bigelow v. Hoover, (Iowa,) 52 N. W. 124.

14. Long Pond, in Concord, whose bed, in its natural condition contains about 160 acres, being navigable within the meaning of the American common law, is the property of the state for the use of the public.—Concord Manuf'g Co. v. Robertson, (N. H.) 25 A. 718.

15. Where the owner of land abutting on Lake Superior

plats it, together with the shallows beyond the shore, the establishment of a dock line inside of some of the submerged blocks, does not divest any property rights therein, but merely regulates and limits their use; so that while the dock line remains in force, the owner cannot use the property for any purpose inconsistent with the public right of navigation; but the change of location of dock line to a point outside of the lots removes this limitation, and amounts to authority from the state to fill in and build out to the new line—Bradshaw v. Duluth Imperial Mill Co., (Minn.) 53 N. W. 1066.

16. The reclamation of the Illinois Central Railroad Co. from the waters of Lake Michigan of a tract 200 feet wide, extending along the front of the city of Chicago, and the construction of its tracks, crossings, guards, etc., and the erection of the breakwater on the east thereof, and the necessary works for the protection of the shore on the west, all as required by the ordinance under which it was permitted to enter the city, did not interfere with any useful freedom in the use of the waters of the lake, for commerce—foreign, interstate, or domestic,—or constitute such an encroachment upon the domain of the state as to require the interposition of a court for their removal, or for any restraint in their use. 33 F. 730 affirmed.—Illinois Cent. R. Co. v. State, 13 S. Ct. 110; City of Chicago v. Illinois Cent. R. Co., Id.; State v. Illinois Cent. R. Co., Id.

17. The railroad company did not, however, acquire by such reclamation, an absolute fee in the lands reclaimed, or any right of use, disposal or control, except for a right of way, and for railroad purposes; nor did it thereby acquire any rights as a riparian owner, to reclaim still further lands from the lake for its use, or for the construction of piers, docks and wharves, in furtherance of its business.—Illinois Cent. R. Co. v. State. 13 S. Ct. 110; City of Chicago v. Illinois Cent. R. Co., Id.; State v. Illinois Cent. R. Co., Id.

18. In respect to the lots lying north of Randolph street, in said city, and the lots in front of Michigan avenue, all bordering on the lake, and to which the company acquired the fee by purchase, it was vested with riparian rights, and thereby became entitled to fill up the shallow waters of the lake, and to construct piers, wharves, docks and slips not extending beyond the point of navigability. 33 F. 730, affirmed.—Illinois Cent. R. Co. v. State, 13 S. Ct. 110; City of Chicago v. Illinois Cent. R. Co., Id.; State v. Illinois Cent. R. Co., Id.

19. The Hudson River Railroad cannot, by virtue merely of the construction of its railroad under charter along the east side of the Hudson river, on land partly below high water, conveyed to it for that purpose by owners of the adjacent uplands, be regarded as an adjacent owner, within Laws 1850, c. 283,

allowing a grant of land under water only to such an owner; and neither can it be allowed to defeat a grant to a private person under said charter of land next under the water to its own, and which does not interfere with its operation, by extending its tracks thereover pending application for the grant under supposed authority conferred by charter to alter its location at any time; and particularly can this not be allowed, as the mere enlargement of its location as proposed is not an alteration within meaning of the charter. 16 N. Y. S. 674, affirmed.—New York Cent. & H. R. R. Co. v. Aldridge, (N. Y. App.) 32 N. E. 50; Saunders v. New York Cent. & H. R. R. Co., Id. 54.

20. The conveyance of land for a railroad right of way, partly above and partly below high water, along the bank of a river, by one owning the adjacent uplands, does not destroy the grantor's character as riparian owner, so that a patent may not issue to him under Laws 1850, c. 283, as to the owner of adjacent land, for the land lying next under the water.—New York Cent. & H. R. R. Co. v. Aldridge, (N. Y. App.) 32 N. E. 50; Saunders v. New York Cent. and H. R. R. Co., Id. 54.

21. Where one, without right, enters on, and fills up land under navigable water, thereby raising it above the water, he acquires no title to such land, and is not an adjacent owner, within the statute—People v. Commissioners of Land Office, (N. Y. App.) 32 N. E. 139.

BUSINESS TRANSACTIONS.

The business meeting of the convention was held on Thursday morning, January 19.

The report of the Secretary was read as follows:

SECRETARY'S REPORT.

Since the reports published in our last Annual the following business has been transacted for the Society:

The annual meeting of the board of directors was held at the Hudson House in Lansing, October 12, 1892. There were present Secretary Hodgman, Director Steele, and members Appleton, Skeels and Sellers.

The members of the board present assumed the right to canvass the votes for officers, and the following were declared elected for the ensuing year: President, E. W. Muenscher; Vice-President, Geo. S. Pierson; Secretary-Treasurer, F. Hodgman; Directors, Wm. Appleton, Dorr Skeels and J. B. Davis.

Messrs. Appleton and Skeels filed their acceptance of the offices to which they had been elected.

The annual report of the Secretary was read and approved.

The annual report of the Treasurer was read and approved.

The memberships of the following persons were declared annulled, for two years' non-payment of dues, as provided by by-law No. 6, viz: James Wiseman, O. S. Heyden, J. Kvam, T. W. Pettee, H. L. Chapin, A. Childs, E. C. Martin, and Willis Baldwin. Communications were read from other delinquent members and action in their cases deferred.

It was voted to hold the next annual meeting in Lansing, in the third week in January, 1893. The Secretary was directed to invite certain members of the Society to prepare papers for the convention, and it was determined to make the road question the leading topic of discussion and to set apart the second day of the convention for that purpose.

The further arrangements for the convention were left to the President, Secretary, and members living in Lansing.

The bill of Geo. E. Steele for $14.85 for expenses attending the meeting of the board of directors, was audited and allowed.

The board then adjourned.

The following are the reports submitted to the board of directors:

SECRETARY'S REPORT TO DIRECTORS.

GENTLEMEN: I would report the following business transacted by me for the Society since the annual convention at Grand Rapids:

Immediately after the convention the job of printing the Annual was let to the lowest bidders, R. Smith & Co., of Lansing, and the copy prepared for them as fast as possible. There was some delay in getting advertisements, but the Annual was out before July 1, and distributed to all of our members not in arrears for dues. Exchange copies were sent to our sister societies in Ohio, Indiana, Illinois, Iowa, to the Provincial Land Surveyors in Canada, and to the engineering societies of the universities at Ann Arbor and Champaign. Return copies of reports have recently been received from all these societies except Ohio and the Provincial Land Surveyors. The Dominion Land Surveyors do not publish any reports this year.

I had 1,500 copies of our Annual published, and we now have on hand enough copies for several other exchanges if they could be secured.

On the first Monday in March I sent out letter ballots for officers and new members to all our members who were entitled to vote, and statements of account to all who were in arrears. I regret to say that but a small per cent. of the members have cast their ballots. On the first Monday in April the ballots for members were opened and canvassed by me and all the applicants found to be elected. On the first day of July I again sent statements to all who were in arrears for dues. On the first Monday in March I mailed to every member who was two years or more in arrears for dues a copy of the by-law No. 6, and the notice required by the by-law. The following members to whom such notices were mailed to their last known address, are still in arrears: J. J. Watkins, James Wiseman, O.

S. Heyden, J. Kvam, T. W. Pettee, H. C. Thompson, H. L. Chapin, E. F. Guild, G. A. Mark, C. B. Hyde, A. Childs, I. Teller, R. B. Merritt (deceased), E. C. Martin, and Willis Baldwin. I hand you herewith letters from some of these parties bearing on the subject. I have received notices of the deaths of John M. Clark and John O. Palmer, and saw an item in a Detroit paper referring to the death of R. B. Merritt, but have not been notified of it by his family.

F. HODGMAN,
Secretary.

TREASURER'S REPORT.

I would respectfully report the following sums as having been received and disbursed by me during the year ending October 12, 1892.

RECEIPTS.

On hand Oct. 14, 1891	$148 01	
Received from annual dues	253 00	
Received from advertisers	260 60	
Received membership fees	47 00	
Received from reports sold	17 50	
Total		$726 11

EXPENDITURES.

Expenses of Board of Directors	$ 11 25	
Express, freight, and drayage	29 07	
Miscellaneous printing	12 83	
Postage and envelopes	56 34	
Cuts and inset for Annuals	58 26	
Printing Annuals	261 37	
Collection fees	1 75	
American Digest	10 00	
Copyright	1 00	
Stenographer	54 00	
Telegraphing	1 12	
Secretary's salary, 1891	100 00	
Balance on hand Oct. 12, 1892	129 12	
Total		$726 11

The society owes nobody a cent.

There is due it from 19 members one year's dues each	$ 38 00
There is due it from 4 members two years dues each..	16 00
There is due it from 6 members three years dues each.	36 00
There is due it from 4 members four years dues each..	32 00
There is due it from advertisers.....	51 00
	$173 00

F. HODGMAN, Treasurer.

Subscribed and sworn to before me this 12th day of October, 1892.

GEORGE E. STEELE,
Notary Public.

The foregoing reports were accepted by the convention.

The following persons were nominated for officers for the next year: For President, E. W. Muenscher; for Vice-President, Geo. S. Pierson; for Secretary-Treasurer, F. Hodgman; for Directors, J. J. Granville, Dorr Skeels, J. B. Davis, James L. Rumsey, A. J. Teed, John McLoughlin and Ernest Sellers.

The reports of the Committee on State Boundary was read and adopted, and the committee directed to prepare and present a memorial to the Legislature. For report and memorial see page 77.

The report of the Committee on Road Legislation was received, discussed, amended and adopted. For report and memorial, see page 181.

Mr. Rogers extended an invitation for the next convention to be held in Port Huron. Mr. Granville gave a similar invitation for Saginaw, Mr. Teed for Cadillac and Mr. Skeels for Grand Rapids.

The Secretary called attention to the fact, that during the past year he had sent out statements three times at intervals of three months to every member in arrears for dues, and after that had drawn through the bank on those still in arrears. Some had paid when drawn on, some paid no attention to statements or draft, and one member considered it an outrage to be drawn on and had withdrawn from the society in consequence. He desired an expression from the society as to the propriety of drawing on members for their dues.

It was voted that the Secretary be directed to draw on

members for their dues when they do not respond otherwise.

It was voted to reprint 500 copies of the first two reports of the society at an expense not to exceed $60.00.

A committee consisting of Geo. L. Wells, Geo. M. Ames, John J. Granville, Henry F. Bean, and John McLoughlin was appointed to solicit advertisements for the Annual.

NOTE.—The Secretary here desires to acknowledge the assistance he has received from Charles Holmes, F. F. Rogers, D. J. Albertson and H. G. Rothwell in procuring advertising for the Annual. It has been of the greatest value and we should have been closely pinched to meet the extra expenses of 1898 without it.

A committee consisting of J. J. Granville, Wm. B. Scars and Seth Dean was appointed to prepare specifications for common roads, and it was voted that the Secretary send out advance copies of the same, previous to the next convention for the consideration and criticism of the members.

The following discussion was had relative to the preparation of papers for our annual convention.

THE PRESIDENT: I think it would be well to have a circular printed and send it around to city engineers and all others whose address can be obtained, soliciting them personally. And if any member of the Society has any subject in which he is interested, to have it suggested, so that others could be requested to write papers on that subject. Now for myself, I find very interesting this street railroad system, which is being very rapidly extended throughout the state. All our citizens are interested in it, and some of our roads are beginning to adopt a form of rail which I think is going to be very dangerous. I should like to have some one familiar with that subject, take it up in a paper—the form of street rails. I am inclined to think that the "T" rail now introduced is very dangerous, and that every city that introduces it, will rue the day. I may be mistaken, but would like to learn the experience of different cities on that point. I requested Mr. McLoughlin to write a paper on that subject, but he was unable to do so. Another thing that would interest me would be a paper on the different kinds of motive power used by street railways. I refer to the cable, electricity, and any other motive power in use. I know that some of our members are as competent as any men in the world, and they could furnish

such a paper as that if they would. I think there are very few of us that could listen to such a paper without learning something; I doubt if there are five members that could explain the operation of the trolley system.

MR. APPLETON: I know there is a man here who if he could be induced to do it, could tell us a great deal about it.

THE PRESIDENT: I should like such a member to gather what he can on this subject, and when we meet again, tell us what the progress has been in electric motors during the past year; it is something that is going to be fresh every year, and yet we come here and neglect these fresh, interesting subjects entirely.

MR. HODGMAN: One of the great difficulties with which the officers of this Society have had to contend in preparing for the convention, was in getting some one to suggest topics, and in getting suitable persons to discuss them. I have sometimes been afraid we should fail entirely on account of the lack of responses. So many have their hands full, and yet some of our best contributors are our hardest worked men. Prof. Davis said, "Don't you know, Hodgman, that if you want to call on some one to do a thing, you must call on some one who has his hands full already." A good many of our very ablest members have never lifted their hands to do anything.

MR. GRANVILLE: The trouble is, a good many of the new members are young men, and are too modest.

MR. HODGMAN: I have urged our young members to prepare things because it is for their own benefit. Nothing will help a young man so much as to take a subject, study it up and write a paper on it. Even if the paper he produces doesn't go to the bottom of the thing at all, it may bring on a discussion and bring out some very valuable thoughts.

MR. APPLETON: In looking over the Society this year, I think while there have been many excellent papers, on a great many subjects, there is a remarkable absence of mechanical engineering. Prof. Cooley has not been here,—Durand has gone from the College, and we seem to have no real live worker in that particular branch. I think this Annual will be very barren. Nothing in the field of electricity—no new

machinery—nothing of that kind ready to go into this Annual, and while we have some excellent things, there is an absence of some other things of a good deal of interest. Mechanical engineering is in its infancy, and is growing more and more interesting.

MR. RANDALL: I would like to second Mr. Appleton's remarks. I think no engineer can do his duty without knowing something of mechanical engineering. Our work is so closely connected with mechanical engineering that it will not hurt us to get some of these treatises on different branches of mechanical engineering.

THE PRESIDENT: I should like very much at our next meeting to have some of our members who are particularly interested in hydraulic engineering give us the results of recent progress in the construction of pumping engines. There has been a wonderful advance in pumping machinery in the last few years.

MR. BEAN: And how few are aware where the latest improvements are.

THE PRESIDENT: I shouldn't be surprised if the Society would be very glad to have Mr. Pierson give us something on this subject.

MR. APPLETON: Very few of you are acquainted with Mr. Jarvis, but he is probably as well posted on the subject of motive power for street railways as any man living, an inventor who has perfected a good many schemes, and I would move it as the sense of this entire meeting, that Mr. Jarvis be requested to prepare for us a paper on the different kinds of motive power used on street railways. I am sure he is capable of giving us a most interesting paper.

Motion supported and carried.

The Secretary was voted $100 for his services during the past year, and a vote of thanks extended to him.

A vote was taken expressing the sympathy of the Society with Mr. Forster in his illness, thanking him for his autobiography, and directing that it be given the place of honor in the forthcoming Annual.

The thanks of the Society were also extended to the President for his earnest work in the convention, to Mr. Sellers for

providing for the local wants of the Society, and to Mayor Bement for the courtesies extended by him.

The convention then adjourned.

MEETING OF BOARD OF DIRECTORS.

A meeting of the board of directors was held during the convention, and applications for membership received and passed upon. Other applications were received by the Secretary and submitted by letter to the board previous to March 1, 1893.

The following persons have been approved for membership by the Board of Directors and elected by letter ballot as members of the Society:

FOR SENIOR MEMBERS.

L. P. Breckenridge, Professor of Mechanical Engineering, Agricultural College, Lansing, Mich.

E. F. Bradt, Mining Engineer and Chemist, Ishpeming, Mich.

B. F. LaRue, Consulting Bridge Engineer, Jackson, Mich.

A. L. Marhoff, City Engineer, Battle Creek, Mich.

E. W. Redman, Civil Engineer, Grand Rapids, Mich.

Ernest Sellers, City Engineer, Lansing, Mich.

M. C. Taft, City Engineer, Kalamazoo, Mich.

William Vincent, Civil Engineer and Surveyor, Manistee, Mich.

T. O. Williams, Civil Engineer and Surveyor, Grand Rapids, Mich.

George F. Bristol, Civil Engineer, Grand Rapids, Mich.

Charles Cummings, Surveyor and Civil Engineer, Marquette, Mich.

FOR JUNIOR MEMBER.

John T. Nellist, Surveyor and Draughtsman, Grand Rapids, Mich.

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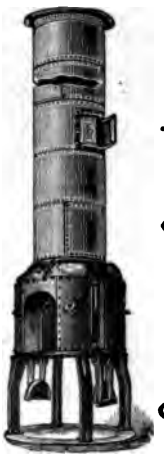

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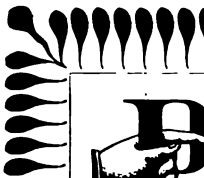

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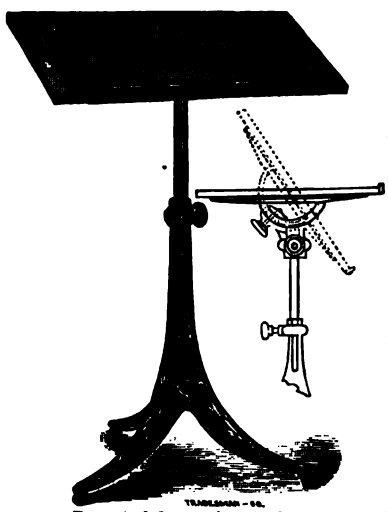

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Silica	3.330
Oxide Lime and Alumina	1.334
Carbonate of Magnesia	.944
Carbonate of Lime	91.538
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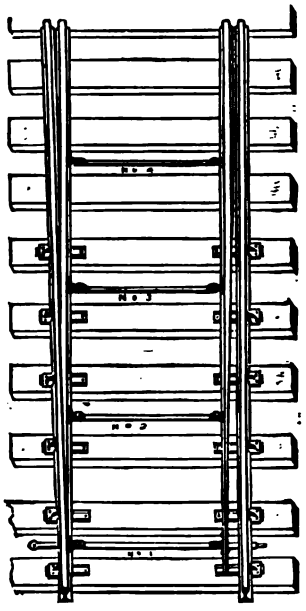

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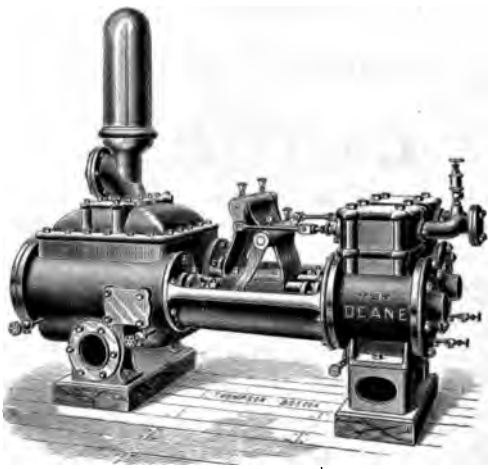

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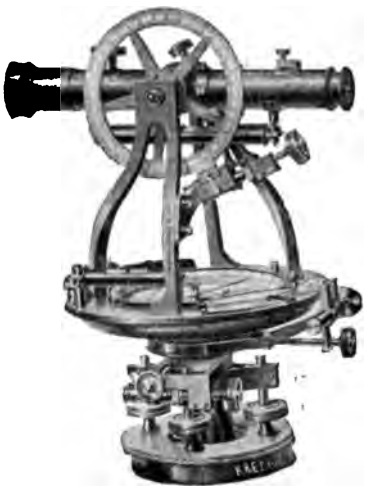

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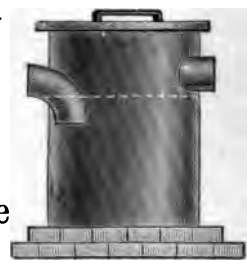

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